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RESEARCH PLANNING AND POLICY

DR. VANNEVAR BUSH, president of the Carnegie Institution of Washington, as witness his recent annual address to the Institution, and the trustees of the Nuffield Foundation and like bodies are much concerned at the present time with the relations between scientists and administrators in research planning and policy. Some of their problems were examined by Mr. C. V. Kidd in an article in *Science* last year (**112**, 147 ; 1953). He directed attention, as Prof. M. Polanyi has done, to the limitations which science itself sets on the freedom of a particular investigator, and he finds a solution to this problem of reconciling initiative and freedom with the direction or planning of research through the recognition that decisions should only be taken at the appropriate level. Those responsible for the decisions regarding the deployment of resources should not attempt to make the decisions regarding the execution or details of particular projects or experiments. Their decisions may and do set limits within which those responsible for the leadership of groups or the carrying out of specific investigations must lay their plans ; but particularly in fundamental work, there should be the greatest possible freedom to select work, as well as to choose means, and to deviate from any predetermined plans.

These arguments, from various quarters, afford ample justification for the concern which has been expressed as to the consequences of excessive dependence of American universities upon Federal funds for the support of their research activities. The independent research institution organized on the lines indicated by Dr. Bush and concentrating on finding the outstanding man and giving him his head is not merely well qualified to sponsor investigations in fields neglected by other bodies and where the prospect is too speculative to justify the commitment of public resources ; it offers at least as good prospects as anywhere else of securing the general agreement and understanding as to the choice and conduct of particular investigations which provide the appropriate atmosphere for creative work and the guidance and development of individual genius. Such conditions are, of course, equally to be found in the universities, and it is by no means certain that the independent institution enjoys quite as much advantage over the university as Dr. Bush suggests. Freedom from teaching responsibilities may be an illusory advantage unless there is something in the contacts between research workers in different disciplines or branches of science which provides the same stimulus, interchange of ideas and inspiration as the close intercourse of different subjects and inter-education of teachers of one subject by those teaching another which Sir Ernest Barker notes as one of the great advantages of the tutorial system at Oxford.

Dr. J. D. Millett's report for the Commission on Financing Higher Education shows clearly that responsible opinion in the United States fully recognizes both the inevitability of sponsored or contract

research, and also the dangers inherent in such research especially when it is sponsored by the Federal Government; nor is there any attempt to disregard the complexity of the issues involved. Probably the greatest danger is that of balance: both staff and other resources are liable to be deflected into specific lines of inquiry, often of a development type, to the neglect of fundamental research. There is also the question of stability arising from uncertainty as to the duration of support; and other questions may arise such as the academic status of the research staff involved and the secrecy requirements hindering exchange of information or publication of results.

Here the principles laid down by President H. W. Dodds, of Princeton University, in a recent statement published in the *American Scientist* (**42**, 128; 1954) offer sound guidance; and they are supported by Dr. Millett's comment that much of this development work proceeds at best on a basis of trial and error because the requisite fundamental knowledge is lacking. Indeed, he goes so far as to suggest that at least half the cost of much applied research in the United States to-day could have been avoided if more basic knowledge had been developed in their universities. Government support of research has proved its value; but the problems which it has brought, notably that of duration, has demonstrated that it does not by itself solve the financial problem of fundamental research. It has, in fact, as Dr. Millett points out, enhanced the importance of other sources of income if universities are to maintain their independence and balance.

Fortunately, it is clear from this report that the prospects of independent benefactions, quite apart from the activities of the independent research institutions or foundations, are brighter in the United States than in Britain. It is not considered that this is a negligible and dwindling source of income, and so long as the present dependence of universities upon Federal funds for support of fundamental research exists, it appears to be possible that income from this source may offset any falling off in the volume of research supported through the defence agencies and especially on a contract basis. How far this hope is justified may well appear doubtful to the disinterested observer, in view of the attitude hitherto adopted by Congress to the National Science Foundation. Although, as Dr. Millett reminds us, a very strong argument can be advanced that the security of the United States is best served by a policy of promoting fundamental research in preference to development research, Congress will have to show a marked change in outlook before real confidence can be felt that it is likely to endorse the continuing support of fundamental research at the universities in the natural sciences by appropriations through the Atomic Energy Commission and the defence agencies which at present administer so much of this expenditure.

Apart, moreover, from the questions of balance and of the discretion to be left in the hands of the university administrators rather than government officials, there are important questions of co-operation—between universities themselves, and between them and the independent research institutions which have hitherto received little attention. It is here that Dr. Millett's analysis of the criticisms of the independent research institutions is valuable. He accepts the view that these institutions—because of their independence—are right to be adventurous, to explore unpopular subjects, to survey fields which government and other agencies shun and to encourage promising talent that has not yet established a reputation. If, however, these bodies are to avoid long-term commitments, and leave to other agencies the task of carrying to completion their successful explorations, there is substance in the frequent criticism of the short-term character of their grants. A measure of co-operation and concerted policy is required at this point, and though it may well in practice come by informal rather than by formal means, neither in the United States nor in Great Britain has the difficulty been entirely resolved.

Probably the inquiries of the National Science Foundation will assist to that end in the United States. In Britain it is obviously engaging the attention of the University Grants Committee, as can be seen from the reference to ear-marked grants in its last report. Neither that body—nor any one formal body—is so constituted as to be able to deal with the problem in all its aspects, though some guidance might well come from the Office of the Lord President of the Council on particular issues. Beyond that it is one to which the Parliamentary and Scientific Committee or the Federation of British Industries could perhaps offer an informal contribution at the appropriate moment, through a joint conference such as those which Nuffield College, for example, arranged some ten years ago on industry and education and on problems of scientific and industrial research.

The second criticism noted by Dr. Millett, that the project approach concentrates attention upon research rather than upon instruction, is scarcely relevant in the present context and in Great Britain. The independent research institution is concerned, by its nature, primarily with the advancement of knowledge, and its contribution to the training of research workers is most effectively made by the continual movement back to the universities or into industry or Government research institutions of young investigators whom it has picked out and trained. The industrial research associations cannot be described as independent research institutions in the sense in which we here understand that term, but it may be noted that part of their proved value to the industries they serve lies in the supply of trained scientists and technologists to these industries, and the educational functions of the research associations are in fact being increasingly stressed. Even the advantages of teaching noted by Sir Ernest Barker would not, however, justify deflecting the work of the research institution from the investigations for which it was established to the task of instruction.

By and large, the research institution's contribution to instruction is made by the continuous process of interchange of workers; and that contribution will be

the more fruitful the more the organization of its projects is such as to avoid the departmentalism which is liable to characterize a university, and to encourage the contact or even conflict of minds across different disciplines which is so fruitful of new ideas. A further criticism, that foundations tend to transfer to their own staffs those functions of the choice of projects for support and the magnitude of the support to be given, has more justification and bears somewhat upon this point. Both points of view will call for constructive thinking in order that frustration and waste of effort and resources may be avoided. President Dodds and Mr. Kidd give indications of the solution, and close and informal contact between the staff of a foundation and the university or research institution such as a reasonable and constant interchange fosters can do much to keep decisions within the appropriate level without encroaching on the competence of others.

It seems clear from these studies that while rather more concern is felt in the United States as to the long-term effects of increasing Federal support of research, the prospects of continuing support from independent voluntary sources are better there than in Great Britain. At least while the present level of taxation persists, it is difficult to give a confident affirmative answer to Lord Beveridge's question whether the succession to the Webbs is secured. Whatever the device with which the society of the future ensures that the spiritual successors to the Webbs have their material resources for research, untrammelled by other duties, by orthodoxy or by prescription of topics, the independent research institutions and the universities will have an essential part to play. That of the Government may well lie less in the direct provision of resources than in seeing that national policy is such that neither fiscal, economic nor any form of political pressure is allowed to discourage initiative, enterprise or the free intercourse of minds and exchange of ideas which are the basis of creative activity and the advancement of knowledge in any field.

IN HONOUR OF CHARLES SINGER

Science, Medicine and History

Essays on the Evolution of Scientific Thought and Medical Practice written in honour of Charles Singer. Collected and Edited by E. Ashworth Underwood. Vol. 1: Pp. xxxii+563+50 plates. Vol. 2: Pp. viii+646+56 plates. (London: Oxford University Press, 1953.) 2 volumes £11 11*s*. net.

CHARLES SINGER, never more learnedly active or intellectually alert than now, in his seventy-eighth year, is a great figure in the history of science, whose influence goes far outside those academic circles to which many of those dedicated to his discipline are restricted. His services in the sphere of learning that he has made his own cannot be set down in a few words, but they comprise outstanding original work in the history of medicine; pioneer exertions as a teacher and as a promoter of the teaching of the history of science; the writing of general text-books; the production of choice and beautiful books for more specialized readers; and the fostering of international co-operation between scholars devoted to the history of science. The two volumes of "Studies on the History and Method of Science", which he edited and to which he contributed outstanding articles, have become much sought-after rarities. Very fitly he is a doctor of medicine, science and letters, for he is Hippocratic, learned and lettered. He has, in the course of a life characterized by a warm-hearted enthusiasm, an informed curiosity and far travel along both the highroads and byroads of learning, gathered together a great body of friends, all gifted but with divers gifts, and some time ago one prominent among them, Dr. E. Ashworth Underwood, undertook the organization of a tribute of admiration and affection from these many men. The present two imposing volumes comprise the essays, ninety in number, offered in homage to one who is the founder of a great and world-wide school of historical research. Dr. Underwood set out on his pious and laborious task many years ago, and since the start fifteen of the authors, including such veterans as dear D'Arcy Thompson, have passed away. To bring together and to edit so many contributions, many of them from distant lands, inevitably takes time. The result is impressive. Dr. Singer has the first claim on our congratulations, the contributors a first claim on our thanks, but Dr. Underwood deserves an ample share of both.

It is not easy in a necessarily restricted space to do justice to studies so numerous, all of great merit and many of outstanding interest, by so many authors, all of profound learning and many of international fame, where the selection of some may seem to suggest, quite wrongly, that all the others are less worthy of note. The variety accords well with the range of the Singers' interests—for Dorothea Singer stands by the side of her husband in these celebrations as in erudite and domestic sympathy. The international character indicates the wide-spread scope of their friendship, for, besides many outstanding contributions from the United States, there are offerings from at least seven European nations. The essays are grouped chronologically in seven "Books" or sections, beginning with the ancient world, Egypt, Greece and Rome. This first section includes an unexpected article on "St. Augustine and Magic", by Dr. Claude Jenkins, in which we find already the legend that the presence of diamonds inhibits the attractive virtue of the magnet, a belief accepted so widely and so late that William Gilbert carried out an elaborate experiment to prove that it was baseless. The next section deals with the medieval world, where we have articles of profound scholarship in remote byways of ancient learning, such as that by Dr. H. E. Sigerist on a fifteenth-century manuscript by Johannes Hartlieb, an early German humanist who brought together gynæcological treatises, and that by Chaim Rabin on the writings of Ibn Jamī', who was physician to Saladin. Names more familiar figure in Dr. Sherwood Taylor's erudite and entertaining article on the Quintessence. Book III brings us to the Renaissance, with, corresponding to his importance, three studies on different aspects of Vesalius. Agnes Arber, an old friend to whom Singer dedicated his "Short History of Biology", is, luckily, well represented by a study in a subject in which she is

paramount, "From Medieval Herbalism to the Birth of Modern Botany". In this group, too, we find a delightful example of light-hearted learning in an essay by Prof. F. J. Cole on Dürer's rhinoceros. It was in 1515 that the artist executed his famous drawing and woodcut of the Indian rhinoceros, or "Gomda", as he called the beast. The eminent zoologist traces Dürer's picture—incidentally, he had never seen a rhinoceros, alive or dead, when the drawing was made—through all the copies, adaptations and transformations down to its last appearance in 1769, with a delightful series of reproductions. Another unexpected study illustrating the diversity of the collection is that, in Book V, by Dr. H. J. Norman on John Bulwer, the seventeenth-century author of "Anthropometamorphosis", a treatise on the deformities and decorations of the human body produced in all parts of the world by fashion. It was a work often cited in Victorian attacks on tight-lacing, but is not much heard of nowadays. A drawing by Daumier comes as somewhat of a surprise in scholarly surroundings, but it illustrates appropriately Dr. Paul Delaunay's brilliant little essay, in Book VII, on P. C. A. Louis as the founder of medical, as distinct from vital, statistics.

To return to our ordered survey, the fourth Book, entitled "The New Philosophy", deals with the period of the reaction against Aristotle and with the beginnings of modern science, while the fifth is concerned with the seventeenth century in general. Here Dr. Arnold Sorsby contributes a very informative article on Richard Banister's services to ophthalmology, the importance of which, we believe, he was the first to stress. Incidentally, articles of ophthalmological interest in the whole work range from Dr. Kurt von Fritz on Democritus's theory of vision to Dr. Dorothy Turner on Thomas Young's work concerning the same subject. Attention may be directed to Dr. Max Fisch's detailed and fully documented study of the little-known *Investiganti* of Naples, an academy which flourished at the time of the *Cimento* of Florence and continued to exist until 1737.

The eighteenth century likewise has a Book to itself, in which Dr. Underwood's contribution is one of the most considerable and, so far as I am able to judge, most original studies, dealing as it does with the text-book of physiology, to use modern terms, written in 1701 by Johann Gottfried von Berger, a name not mentioned in Garrison's "History of Medicine" or other well-known histories of the subject. The Book on the nineteenth century and after contains seventeen papers, of which Sir Geoffrey Jefferson's very frank but sympathetic treatment of Marshall Hall's work on reflex action is certainly not the least interesting.

The book concludes with a series of studies of general import contributed by famous names, such as Dr. Redcliffe Salaman, Dr. John Fulton, Prof. C. D. Darlington and Dr. Joseph Needham, as well as, among younger men, Mr. H. T. Pledge. Perhaps it is typical of the quality and scope of the whole collection that whereas the first essay of all is a brilliant survey of the growth of archæology to its modern position as a science, by Prof. Gordon Childe, the last is a charming collection of reminiscences by Charles Sherrington, whose early hero, Fernel, figures frequently in the essays. This brings to mind a feature of the editing that deserves a special word of commendation, namely, the indexes of persons and subjects, which are particularly full, well designed and well carried out, and are an invaluable addition to a work of this kind. Thus, if one wants to know what is said of Fernel in different places, one has only to turn to his name to find the various references descriptively set down, not just paged.

Famous names, in themselves a guarantee for the excellence of their contributions, which have not even been mentioned are Dr. George Sarton, founder and editor of *Isis* and *Osiris*; Prof. J. R. Partington; Dr. Gavin de Beer; Sir Zachary Cope; Prof. Herbert Dingle; and Dr. Douglas McKie—and there are others. The survey which this notice has been able to offer is slight, the selection of essays for mention arbitrary; all that can be hoped is that the reader will have gathered the impression that here is a book which any lover of learning, especially one with historical and bibliographical tastes, can pick up, open anywhere and read with the greatest pleasure and profit, or, alternatively, of which he can in lazy mood turn the pages, look at the pictures and read odd passages, to be lured to more serious attention. It is an ideal book to take up for after-dinner entertainment, a hard book to put down. Let us conclude with a quotation from D'Arcy Thompson's feeling study entitled "The Golden Ages", in which he considers how particular periods have been outstanding in different countries for exceptional achievement in science and art—"But we may turn from the wayside and the market to watch the kindly faces of a little company of unworldly men. They are not (as I see them) the faces of statesmen, nor warriors, nor even artists, authors, poets: they are just the earnest student-faces of far-seeing and deep-thinking men"; and after the citation of great names in science of the period from Faraday to Rutherford and Planck—"Some of these dwell among the Gods, the rest are Heroes. And our children's children will look back on the great century of science to which they belong, and will know it for a Golden Age".

E. N. da C. Andrade

FRESHWATER ECOLOGY

Fundamentals of Limnology

By Dr. Franz Ruttner. Translated by Dr. D. G. Frey and F. E. J. Fry. Pp. xi+242. (Toronto: University of Toronto Press; London: Oxford University Press, 1953.) 52*s.* net.

THOSE engaged in teaching freshwater biology have for long felt the lack of a satisfactory text-book, and many must have wished Prof. F. Ruttner's "Grundriss der Limnologie" were available in English. This wish has now been answered by two professors, one American, the other Canadian, who both set out independently to translate the book and only heard through a mutual friend in Scotland of each other's intentions. The result was their collaboration in the present volume.

The first half of the book gives a clear and concise account of "Water as an Environment" in two sections covering respectively the "Physical Properties of the Environment" and "Dissolved Substances and their Transformations". The approach is essentially ecological, and the information is presented as the physico-chemical background which is fundamental to an understanding of the biology of fresh waters. The second half is devoted to "Biotic Communities" and is divided into four sections of unequal length covering plankton, and other communities of lakes,

bogs and running water. The longest and most interesting of these is that on plankton. Here the author's point of view is primarily, though not exclusively, chemical; but what is known of the physiology of the organisms is also taken into account in discussing their ecology, and occasional comparisons with the sea are illuminating. If there are aspects of the subject which receive rather scant treatment, this is compensated by the author's stimulating ideas on others. This section really hangs very closely on to the first half of the book.

With the change of subject to "The Other Communities of Lakes" the treatment becomes much less exhaustive, and one is conscious that the author is a little outside his own particular field. But the section on "Communities of the Ooze", where the point of view is again mainly chemical, is as interesting and stimulating as anything in the earlier parts of the book. There is here an admirably lucid exposition of the fundamentals of this intricate and complex system.

The translation is so good that one is only very occasionally reminded that the original was not written in English, and there is a useful list of the words the translators have adopted as equivalents for some of the technical terms of the subject. While some of these seem too obvious to be worth mentioning, one wonders what led them to coin the words 'highmoor' and 'lowmoor' [*sic*] for *hochmoor* and *flachmoor* instead of using 'raised bog' and 'valley bog', respectively. It may be that limnologists do not use these terms as precisely as plant ecologists; but these do in fact seem to be the senses in which Prof. Ruttner uses them.

But the smallness of these criticisms is an indication of the general excellence of the book, a fact which no limnologist would dispute. Not only does it gather together much of the information scattered in the literature and weave it into a well-knit whole, but it also throws a flood of light on Prof. Ruttner's insight into many of the problems of the subject in a way which none of his previous publications do. The only amendment I would propose to the translators' assessment of it as "perhaps the best book available in any language on the principles of limnology" would be to substitute "undoubtedly" for "perhaps". All British and American workers in the subject will be grateful to Profs. Frey and Fry for making it available in English.

H. C. Gilson

HEALTH AND SICKNESS IN BRITAIN DURING WAR-TIME

The Civilian Health and Medical Services

Edited by Sir Arthur Salusbury MacNalty. Vol. 1: The Ministry of Health Services; Other Civilian Health and Medical Services. (History of the Second World War: United Kingdom Medical Series.) Pp. xi+441. (London: H.M. Stationery Office, 1953.) 45*s*. net.

"WAR is the enemy of health." Yet wars in our recent history have been a direct stimulus to progress in medical science and the development of health services. This volume tells the remarkable tale how, after a brief set-back in the early days of the Second World War, steady improvement in the public health went on in Great Britain as measured not merely by falling mortality-rates but more positively by steady advance in the physical development of the nation's children.

No doubt we were lucky in some of our escapes from epidemic diseases, for example, the long-awaited and much-dreaded influenza epidemics which never came. But it was by no means all luck. Intensive planning for the war emergency began at the Ministry of Health two years before the outbreak of war, and the British Medical Association along with the Royal Colleges of Surgeons and of Physicians played their part by preparing, and later carrying out, the mobilization plan for the medical profession.

War gives courage to make long-needed reforms. The Emergency Public Health Laboratory Service was one of the great innovations of the War. Yet Sir John Simon had foreseen the need last century, and his successor at the Local Government Board, Sir Arthur Newsholme, pressed the need for it, in season and out, and would have achieved his object but for the outbreak of the First World War. This Service was introduced in anticipation of great epidemics. These never materialized, but the laboratories were brought into permanent place in our health services by Dr. G. S. Wilson's bacteriologists, who did much to raise national standards of diagnosis. Chlorination of water supplies was introduced against the increased risk to water supplies from air raids and lesser war-time threats, and this, too, became a permanent feature of our public health control. The diphtheria immunization campaign was one of the great achievements of the War; its importance can be measured against the experience of the Channel Islands, which were exposed to the severe Continental epidemic of diphtheria in 1942–43. The Ministry of Health was allowed to introduce by radio frank and realistic discussion on venereal diseases, and public opinion, well ahead of its guardians as often, received this without dismay.

The epidemics of cerebro-spinal fever during the years 1940–42 were sharp and unpleasant, and followed precedents established during the Napoleonic Wars, the American Civil War and the First World War. We were more fortunate than our forbears because of recently developed and effective chemotherapy against this killing disease. Epidemic hepatitis was another traditional war-time disease which gave a good deal of trouble. No specific remedies were available; but a great deal was learnt about the natural history of the disease, and the related scourges—serum jaundice and post-transfusion jaundice, this latter being a bitter by-product of the brilliantly successful war-time blood-transfusion services.

Our fortune with tuberculosis was mixed. In the early days of the War chronic infectious patients returned home from sanitoria beds emptied in anticipation of air-raid casualties. This and war-time conditions brought a rise in the tuberculosis death-rate during 1940–41. Among adults it was older men, not young women, as in the First World War, who fared worst. The most disquieting feature was the increase in deaths among young children from pulmonary tuberculosis and meningitis. Later the tuberculosis death-rates resumed their pre-war downward trends. Notifications, however, continued to rise, partly at any rate due to improved means of diagnosis, and with rising notification-rates came prolonged waiting-lists for admission to sanatoria. The threat from tuberculosis had its valuable achievement in certain innovations, notably the introduction of mass miniature radiography and the system of

tuberculosis allowances to encourage the early diagnosed case to accept treatment.

Undoubtedly the greatest achievement of all was in the field of nutrition. The rationing policy was the result of pre-war research. Long before the War, emergency food policies had been outlined, and at the outbreak of hostilities the new Ministry of Food accepted as the essentials of its policy not only the need to economize in shipping space but also the equitable distribution of food, with special attention to those on whom the future depended—that is, children and expectant and nursing mothers. Apart from rationing, the raising of the extraction-rate of flour, the development of school milk and meals, and the encouragement of factory canteens were important features of policy.

It is an unexplained wonder that the overcrowding in air-raid shelters produced so few ill-effects. After the first crisis and blundering of the 'blitz' were over, devoted efforts were directed to the improvement of sanitation and ventilation in the shelters and to the development of medical services and epidemiological studies. All these things must have helped, but they do not explain the providential escape from disease.

Not least among the effects of the 'blitz' was the introduction to each other, through the evacuation, of Disraeli's two nations. The discovery that head lice, impetigo, ringworm and bed-wetting were common was a surprise only because we had shut our eyes to these things in peace-time. In coping with these problems, the School Medical Service played a major part, and it should not be forgotten that the Education Act of 1944, passed in war-time, was an important health act as well as a new policy for education.

In industry, too, there were notable advances. The Factory Department was transferred to the Ministry of Labour and National Service in 1940, and played its part under that Ministry in mitigating the strains of war-time production and black-out conditions. The Factories (Medical and Welfare Services) Order 1940 had its outcome in the spread of medical and nursing services in industry, and in the multiplication of industrial canteens. The Ministry of Supply developed its own industrial medical service to control the serious toxic hazards in ordnance factories, and with a considerable measure of success.

Not least among the interests of this volume is the story of the health services of the Channel Islands during the German occupation. Finally, as a commentary on Britain in war-time, it is worth recalling that the first planning and negotiations for the National Health Service began early in 1943 when the end of the War was still very far from view.

J. H. F. Brotherston

HEALTH AND SAFETY IN AVIATION

Human Factors in Air Transportation

Occupational Health and Safety. By Prof. Ross A. McFarland. Pp. xv+830. (London: McGraw-Hill Publishing Co., Ltd., 1953.) 106*s*. 6*d*.

In an earlier book, "Human Factors in Air Transport Design", Dr. R. A. McFarland, who is professor of industrial hygiene at the Harvard School of Public Health, made an admirably bold and very useful attempt to provide designers of aircraft with information about ways in which they should 'make allowance' for human capacities and inclinations in their aeronautical engineering. In the present book he goes several stages further and offers a multitude of facts and opinions to specialists in aviation medicine, personnel managers, safety experts, and to many more; and, as before, he performs his task in a thoroughly businesslike fashion. Not the least commendable feature of the book is its lucidity. There can be no doubt that from this point of view it will prove an unusually acceptable guide to the layman. Dr. McFarland takes an immense amount of trouble to make himself clear. This shows itself not only in his careful explanation of technical points in ordinary language, but also in his thinking about them (for example, in his use of the substantival, assumption-free term 'accident repeater', on p. 73, for the adjectival, theory-ridden 'accident prone').

The ground he covers is clearly indicated in his well-planned contents pages. After an introductory chapter, which finishes with an assertion of the view that the ultimate success of air transportation will depend on the extent to which the characteristics of its operating and maintenance personnel are understood and the social habits and needs of its passengers recognized, he goes on to deal with the selection and training of flight personnel and the selection, placing and health of ground personnel. He ranges widely in these fields and presents a number of useful summaries of work done in them, particularly during the Second World War. But sometimes he attempts so much that he lays himself open to a charge of superficiality. Indeed, some of his efforts at condensation lead to rather puzzling statements. For example, on p. 41 he remarks, "Once the tests were found to be of predictive value, the next step was to determine a valid criterion for success in combat". He may perhaps argue that the context made it unnecessary to add the words 'for success in training' after 'predictive value', but surely the saving was scarcely worth while. Again, on p. 75 he appears to fall into the common trap of regarding rating scales as instruments for producing judgments rather than as mere recording devices. Faults of these kinds will not seriously diminish the value of the book to knowledgeable readers, but they may mislead the non-expert.

Dr. McFarland's chapters on safety on the ground and in flight make good reading, not least because they give him scope for his obvious taste—already displayed in his chapter on the indoctrination and training of flight crews—for formulating plain rules of procedure, securely rooted in careful reflexion on relevant evidence. He seems equally at home in his chapters on sanitation and health in airline operations; but—not unnaturally—he is rather less confident when he comes to examine problems arising in the care of passengers and the transportation of patients by air, for in many respects these must be regarded as relatively new. In his final chapter, Dr. McFarland discusses the organization and functions of air-transport medical programmes. So wide and deep is the territory he wants aviation medicine to annex, that a bystander may well wonder where people competent to administer it will be found in the numbers that this immense work will require. But no harm can be done by his thoughtful exposition of his grand ideas. Anyway, it makes a fitting end to a fascinating book.

Alec Rodger

Organic Syntheses

An Annual Publication of Satisfactory Methods for the Preparation of Organic Chemicals. Vol. 32, 1952. Edited by Richard T. Arnold. Pp. vi+119. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1952.) 28*s*. net.

OF the forty-five preparations described in this volume, the first is an improved method for preparing abietic acid from wood rosin; and the last deals with the conversion of 10-undecenoic acid into 10-undecynoic acid, the double bond being converted into a triple bond by successive treatment with bromine and sodamide. Other methods of introducing triple bonds are illustrated by the use of acetylene and of calcium carbide in the respective preparations of β-chlorovinyl *iso*amyl ketone from *iso*caproyl chloride and of 1,1′-ethynylene-*bis*-cyclohexanol from cyclohexanone. The great variety of processes here displayed may be illustrated further by mentioning the preparations of alloxan monohydrate from barbituric acid, cyanogen iodide from sodium cyanide and iodine, 1,2-cyclohexanedione-dioxime from cyclohexanone, and cyclohexene sulphide from cyclohexene oxide. While a new method, due to Prof. T. S. Wheeler, is given for the direct production of flavone from *o*-benzoyloxyacetophenone and anhydrous glycerol, the application of the Baker–Venkataraman transformation is recommended because of the high yield and reproducibility of this procedure. Essential precautions and experimental detail are admirably set out: for example, in preparing 2,2′-dichloroethanol from dichloroacetyl chloride and lithium aluminium hydride, the use of a good hood and a spark-proof motor is prescribed; glassware is dried by flaming during the passage of dry nitrogen, and directions are given for pulverizing the hydride. The subject index covers Vols. 30–32.

JOHN READ

Toxicity of Industrial Organic Solvents

By Ethel Browning. (Revised in consultation with the Toxicology Committee.) (Medical Research Council: Industrial Health Research Board, Report No. 80.) Revised edition. Pp. viii+412. (London: H.M. Stationery Office, 1953.) 35*s*. net.

IN this revised (1952) edition, Dr. Ethel Browning has summarized, in the light of the results of work published up to the year 1948, the toxic action of some organic solvents and the possible effect of this on the health of workers in industrial processes where these solvents are used. The summary includes both the older and better-known solvents, and also some which have only recently become available in commercial quantities. The new edition appears at an opportune time, since solvents of all kinds are being used in increasing quantities in a variety of industrial operations.

The arrangement of the subject-matter follows closely that adopted in the first edition. For each solvent the relevant physical properties are listed, together with the requirements of any existing recognized standard specification for controlling the quality and composition of the solvent. The importance of some knowledge of the chemical composition of the solvent, in relation to any toxic effect observed in its use, is indicated by the author in comments on the results of some of the published work. The symptoms which characterize cases of acute and chronic poisoning, in both animals and man, are fully described, and for a number of solvents useful data are given as to what, in the opinion of some authorities, should be regarded as a maximum safe concentration of the solvent vapour in air.

The book is a worthy successor to the first edition, and should prove of considerable help to all concerned with the health of workers in the manufacture, transport or use of organic solvents.

Volumetric and Phase Behavior of Oil Field Hydrocarbon Systems

By Dr. M. B. Standing. Pp. vi+123. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1952.) 80*s*. net.

THE complex behaviour of varied types of hydrocarbon systems encountered in oilfield reservoirs has engaged the attention of petroleum engineers for many years past. Much has been done and much written on specialized methods of calculating pressure-production characteristics of subsurface oil and gas pools. This volume approaches the subject from the less conventional angle—co-ordination of laboratory measurement data on fluids, and the manner in which these data can be used to calculate actual reservoir behaviour. When we consider that under normal oilfield conditions vastly different hydrocarbon systems are co-existent; that types vary from a simple gas such as pure methane to the highly complex asphaltic bitumen; and that these types are constantly changing with pressure and temperature as affected by production; then it at once becomes apparent that problems to be faced require for their solution a sound knowledge of mechanism of fluid flow, thermodynamics and a nicely balanced interpretation of all facts elicited. Treatment of the subject in this book is systematic, based on division of hydrocarbon types into gases, condensate systems and dissolved gas systems. Phase behaviour of these systems, sampling of oil reservoirs and material-balance calculations support the discussion. Numerous charts are included to aid calculations for specific reservoir conditions, and the general set-up of text and clear printing add greatly to the value of the work, without which oil-pool specialists will lack a very modern approach to this ever-difficult subject.

H. B. MILNER

Contributions to the Theory of Nonlinear Oscillations

Vol. 2. By M. L. Cartwright, E. A. Coddington, H. F. DeBaggis, S. Lefschetz, N. Levinson, J. McCarthy, H. L. Turrittin. Edited by S. Lefschetz. (Annals of Mathematics Studies, No. 29.) Pp. vii+116. (Princeton, N.J.: Princeton University Press; London: Oxford University Press, 1952.) 10*s*. net.

THIS monograph is a sequel to No. 20 of the same series. The following articles appear in it: Van der Pol's equation for relaxation oscillations (Miss M. L. Cartwright); perturbations of linear systems with constant coefficients possessing periodic solutions (E. A. Coddington and N. Levinson); dynamical systems with stable structures (H. F. DeBaggis); notes on differential equations (S. Lefschetz); a method for the calculation of limit cycles by successive approximation (J. McCarthy); and asymptotic expansions of solutions of systems of ordinary linear differential equations containing a parameter (H. L. Turrittin). These represent contributions to the theory of differential equations; and virtually no attempt is made to discuss physical significance, let alone practical utility of the topics discussed.

THE ROYAL SOCIETY OF ARTS

BICENTENARY CELEBRATIONS

THE first official meeting of the Society of Arts took place on March 22, 1754, and the exact anniversary two hundred years later fell on a Monday, so that the first day of a week of celebrations was also in some respects the most important.

On March 22, 1954, three events were arranged, two of them of more or less public a character and the third private. The celebrations opened with a service at the Church of St. Martin-in-the-Fields, when the Society met probably for the first time in its history in such a building and for such a purpose. But the service was unusual not only because of its uniqueness in the Society's history, but also in its own character, and particularly from the musical point of view. As the organ was under repair, the singing was accompanied by an orchestra which, together with the choir, was provided by members of staff and students of Trinity College of Music, under the direction of the principal, Dr. Greenhouse Allt, who is a Fellow of the Society. One item of music was of special interest, the Trio Sonata No. 2 of Thomas Augustine Arne, who was one of the early members of the Society. The sonata has only recently been published, and this was probably its first public performance for 150 years. The execution of the music was throughout of a very high quality and the *Te Deum* (Vaughan Williams in G) in particular formed a most impressive climax to the service. The sermon was preached by the Bishop of Peterborough, who reviewed from the spiritual point of view the bewildering scientific and material progress of the past two hundred years and closed with the words of Francis Bacon : "The final end of all knowledge is the glory of the Creator and the relief of man's estate".

In the afternoon the chairman of Council, the Earl of Radnor, who is the lineal descendant of the Society's first president, Viscount Folkestone, received congratulatory addresses from representatives, in most cases the presidents, of nearly sixty other organizations, many of which, and in particular several from overseas, owe their origin in some degree to the activities of the Royal Society of Arts. It was a colourful scene as the representatives, many of them in academic robes, advanced singly, and with a quiet dignity befitting the eighteenth-century room in which the ceremony took place, to present the tribute of their organization. The ceremony concluded with a short address from Lord Samuel, retrospective but never nostalgic, in which he called upon the members of the Society of the present day to exercise the same faith and hope as moved the Society's founders and to sustain their good work for the sake of the generations that are still to come.

The day's events concluded in a more private manner, when the members of the Society's Council and their ladies dined informally at Tallow Chandlers Hall, and in this way commemorated the fact that the Society's first meeting took place in somewhat similar surroundings at Rawthmell's Coffee House. After dinner, students of the Royal Academy of Dramatic Art presented a scene from "She Stoops to Conquer" : Goldsmith was not only one of the early members of the Society, but was also actually an applicant in 1760 for its secretaryship.

On the afternoons of Tuesday, Wednesday and Thursday a series of three masterly addresses was delivered by Prof. N. B. L. Pevsner, Sir Ben Lockspeiser and Sir Geoffrey Heyworth, on the progress of "Arts", "Manufactures" and "Commerce" respectively during the past two hundred years, this pattern of themes being based on the Society's full title, "The Royal Society for the Encouragement of Arts, Manufactures and Commerce". Prof. Pevsner concentrated mostly on the history of industrial design during this period and, while recounting its promotion by the Society at various periods during the two hundred years, particularly emphasized the influence which it exerted in the years succeeding the Great Exhibition by its forthright attitude to contemporary design. Sir Ben Lockspeiser, in a survey of science in its application to industry during the past two hundred years, looked back, as it were, to Prof. Pevsner's lecture and emphasized the need for improved technology to go hand-in-hand with imaginative design, and looked forward to Sir Geoffrey Heyworth's subject, hinting at the contribution which science can now make to accountancy and many other clerical operations. In the last of the three lectures Sir Geoffrey Heyworth, in dealing with the subject of "Commerce", concentrated his attention upon the history of education for commerce, to which the Society itself has made and continues to make so important a contribution, and, in surveying the past two hundred years, he showed what had been achieved, first by the ordinary day school, then by institutions mainly operating in the evenings for specific training for commerce, and finally, through the acceptance of commercial subjects as appropriate to a university.

The fitting conclusion of the week's celebrations was a banquet, the first official dinner of the Society for ninety-two years, which was held at the neighbouring Savoy Hotel on Friday evening and at which T.R.H. the Duke and Duchess of Gloucester were present. Lord Woolton, a Fellow of the Society, represented Her Majesty's Government, and the Lord Mayor of London was there to represent civic government. In proposing the toast of the Society the Duke of Gloucester emphasized three aspects of its character, which he termed its disinterestedness, its humanity and its ability to combine the virtues of youth and age. Lord Radnor replied, and responses to the toast of the guests, which was proposed by Sir Ernest Goodale, were made by Dr. E. D. Adrian, speaking for the men guests and science, and Dame Ninette de Valois, representing the ladies and the arts. Dr. Adrian emphasized the influence which the Society, as a body interested equally in the arts and the sciences, could exercise towards securing that the discoveries of science were applied in a way that was beneficial and not harmful to the community, while Dame Ninette appealed to it for its support for the youngest of the arts.

Fortunately this festive week does not entirely complete the Society's celebrations of its bicentenary, as it is able to look forward to a reception which is being arranged to be held at St. James's Palace later in the year when its president, H.R.H. the Duke of Edinburgh, whose absence at this time was so keenly felt, can hope to be present.

In addition to these special events, the Society is commemorating its bicentenary by several actions of varying kinds. Its bicentenary competition, in which

ideas of life in A.D. 2000 were invited, has already been announced. The Council has also decided to institute a medal, to be known as the Bicentenary Medal, which will be awarded annually to a patron of industrial design, and a new history of the Society prepared by Mr. Derek Hudson and the Secretary was published on the day of the bicentenary. Also, a beautiful badge of office for the Chairman of Council designed by Prof. R. Y. Goodden has been presented to the Society by a former chairman of Council, Mr. J. A. Milne, and the Chairman was invested with this for the first time on March 17 in readiness for the forthcoming bicentenary functions.

KENNETH W. LUCKHURST

SUN NAVIGATION BY ANIMALS

By DR. H. KALMUS

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IT has for a long time been suspected that sun navigation must play an important part in the movements of homing and migrating animals; but until recently the evidence for its existence was not convincing, often contradictory, and the way in which it could work remained mysterious. However, experiments published during the past two years on honey bees[1], amphipods (*Talitrus saltator*)[2] and birds[3,4] have not only demonstrated the existence of sun navigation beyond doubt, but have also shown that it is based in all three groups on a combination of two widely found faculties, namely, the perception and memory of angles and a change according to a twenty-four-hour rhythm of a reference system operating in the brain of the animal. As the orientational behaviour of honey bees is better known than that of the other species, it will be discussed first.

Worker bees, in a dark hive-like container, have been shown to perceive and to remember the angle between two straight parts of a learned track with great facility[5], and it has long been established that in the outside world they make use of their sense of direction when flying between their hive and a feeding place[6].

A combination of indoor and outdoor orientation is the basis of the bees' communication of direction: a forager by dancing on a vertical comb in the dark indicates, by the angle and direction of deviation from the vertical, the angle and direction of a rich source of food from the direction of the sun[7].

It was believed for a long time, and on some evidence, that honey bees, once they have learned the angle between the sun and a source of food, will retain this angle unchanged in their memory and will accordingly, like certain ants[8], strike out in a wrong direction, when they have been forced by the experimenter to remain inside the hive, the deviation depending on the length of their captivity. Lately, however, v. Frisch[1] has demonstrated that bees "when orientating with the aid of the sun, take the hour of the day into account". During several fine days he fed bees at an anise-scented syrup dish 200 m. west from their observation hive. The colony was then removed to a neighbourhood which was quite unfamiliar to the bees, and four identical syrup dishes scented with aniseed were laid 200 m. to the north, the south, the west and the east from the hive. Within three hours, twenty out of twenty-nine bees marked in the first location at the dish on the previous day were caught at the dish west of the hive and seven at the three others; and this happened although the sun had stood in the west when the bees had last fed at the first place, and in the east when they were caught at the second place. Repetitions of this type of experiment using additional precautions against other clues had similar results; but the orientation broke down when the sky was overcast. Additional evidence for a mechanism compensating for the daily movements of the sun is provided by an observation by Lindauer[1] on an exceptional dancer, who after having found a dish did not leave the hive after 1–2 min. as is the rule, but continued to dance for eighty-seven minutes on a vertical comb. During this time the angle of the axis of the dance with the vertical changed by about 33°, while the movement of the azimuth at the place and time of the observation was 34·5°. Thus there can be little doubt that bees when finding a direction make use of some device which compensates for the daily movements of the sun or perhaps for the changes in the polarization pattern of the sky associated with it which they are known to use in other circumstances. While the possession of this compensating mechanism must be considered to be innate, its setting—like that of an automatic steering device—is effected for any situation, as opportunity arises.

The second example of sun navigation concerns the little crustacean *Talitrus saltator*, an abundant inhabitant of many sandy beaches in the Mediterranean. These animals when transferred inland will move at a right angle towards the coast-line from which they came, which will normally result in their regaining their habitat. Recently, Pardi and Papi[2] have shown that to do so they make use of the position of the sun. When the sun was shielded from a few of these crustaceans and was replaced by its mirror image from the opposite direction they moved away from the shore instead of towards it. Like the bees, they could also orientate themselves when in the absence of direct sunlight, provided that some portion of the blue sky, but larger than that necessary for bees, was visible to them, and they could also be deflected by the application of a polarizing sheet. The directions of their movements were independent of the hour of the day, and thus of the changing position of the sun, but dependent on the place of origin of the animals: individuals from a population of the Tyrrhenic coast of Italy, for example, moved westwards, even when brought to the Adriatic coast, while the indigenous animals there moved eastwards. As with the bees, one must assume that the mechanism which compensates for the daily movements of the sun is innate in *Talitrus*, but unlike bees these crustaceans cannot set the geographical direction in which they move by individual experience; it seems to be set for each of them once and for ever either by heredity or by early individual experience.

Similar observations were also made on pigeons, starlings and other birds. Kramer[3], experimenting with starlings, showed that these birds, like *Talitrus*,

have innate direction preferences, which come into play during migration, but that—like bees—they can also be trained to any geographical direction. In both reactions compensation for the daily movements of the sun was observed; but as might be expected from the structural differences between an arthropod's and a vertebrate's eye, the polarization of sky light does not play an important part in this. The innate preference for a particular geographical direction was established by closer observation of a well-known phenomenon: the migration during certain hours of the day of caged migrant birds. Young starlings of supposedly east Baltic origin, kept since July in an outdoor aviary in Wilhelmshaven, showed later in the season a distinct tendency to 'migrate' south-west, that is, in the direction of their presumed origin. This directional tendency was manifest in a round cage of about 2 ft. diameter; it persisted both in conditions which excluded the sight of the horizon and in the presence of great masses of iron, which greatly altered the direction of the compass needle. Orientated flight seemed impossible when the bird could not see the sky, or at least portions of it; but directional flight was observed when a starling was placed in the centre of a hexagonal pavilion, with six windows. When a mirror was attached to every window so that the incident light was deflected by 90° while the direct sky light was shielded off by a blind, the bird's main direction of flight was also deflected by 90° and in the same direction as the light. This type of experiment and similar ones showed that the migrating starling's behaviour was, in fact, governed by the incident light.

Kramer also performed experiments based on direction learning. Twelve equal feeders were placed in a circle around the starling on a movable ring, and covers were mounted on a second ring gliding upon the ring bearing the feeders, giving the experimenter great freedom of action. The food in the feeders was hidden from the birds and could be reached through a slotted rubber membrane. In the absence of landmarks starlings fairly soon learned to visit a feeder in a particular geographical direction, and after a fortnight some birds were perfect. Applying the mirror test as in the migration experiment, such trained starlings were deflected by 90°, thus showing that it was again the incident light which directed the bird. The 'right' feeder was also visited at various hours of the day, thus again showing that the daily movement of the sun was taken into account. On the other hand, it proved very difficult and took a long time to train a bird to keep visiting a feeder which was moved along during the days with the azimuth of the sun. Trained starlings did not perform well under heavily overcast skies, but orientated themselves to artificial light sources in place of the sun. Matthews[4] has shown that pigeons can not only utilize the azimuth of the sun to get their bearings when returning to their loft from a direction to which they had been trained, but that many of them also return quickly from distant places in various directions. He has put forward a complex hypothesis to explain these results, in which it is assumed that the birds utilize not only the azimuth but also the altitude of the sun for their orientation.

The enumeration of these examples must make it unreasonable to doubt any longer the existence of diurnally changing reference systems for the sun orientation of many animal species. While one might be inclined to favour the simplest hypothesis which can explain sun navigation, it may in fact be quite complex: there cannot be much doubt that moon-navigation would require very intricate astronomical reference systems; and yet many ornithologists believe in the moon navigation of night migrants, and it has also been fairly convincingly demonstrated for *Talitrus*[9].

Geographical direction may play some part in the orientation of animals, other than when homing or migrating. Bees in the field, for example, seem acutely aware of the geographical direction; they could be easily trained to visit a dish on a card the western half of which was yellow while the eastern half was blue; they did not visit dishes on cards orientated in the opposite direction, and their visits on the correct cards were independent of the position of the feeding site in the field and of the hour of the day[10]. The well-known straight north–south orientation of the board-like mounds of certain North Australian termites[11] (*Hamitermes meridionalis*) may be another example of geographical orientation. While plausible ideas have been developed concerning the advantages of such orientation for the temperature regulation of the mounds, no hypothesis about the orientation of the termites during their building activity could previously be advanced. One now might perhaps assume that these termites also possess a brain mechanism which compensates for the daily movements of the sun.

The brain mechanisms which serve the sun navigation of the animals mentioned are presumably of a similar nature in all species and are probably based on the same principles as human sun orientation. They can also be expected to share certain properties with other time-keeping mechanisms (internal clocks) which are of wide occurrence[12–14]. They keep time fairly well on their own and they are set and kept in pace by light stimuli. Their metabolic nature has in certain cases been established[13]. A third property of such systems is that they regulate motor activities. *Drosophila*, for example, normally emerge from their pupæ before dawn. If a bottle with larvæ and pupæ of *D. melanogaster* is artificially illuminated during three consecutive nights and kept in darkness during daytime, the flies which emerge during the following week will 'remember' the time of the artificial dawn and emerge in the evenings, even when now kept in perpetual darkness[15]. Examples of this sort could be multiplied; but while they would show that the elements for timing systems in animals very generally exist, they would not greatly add to our understanding of the details of sun navigation. These can only be explored by further experiments.

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PHYSICAL INSTABILITY AND THERMAL SHOCK IN RED CELLS

By Dr. J. E. LOVELOCK

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THE idea that vital processes might be suspended at low temperatures has inspired attempts to preserve living cells in the frozen state. Success was rare because of the particularly destructive effects of the act of freezing and because it was not realized that each type of cell might require an individual technique of freezing. It was discovered in 1949 [1] that the death of spermatozoa on freezing could be avoided if the cells were suspended in a medium containing glycerol, and this removed at one stroke the main barrier opposing the preservation of living cells in the frozen state. Since that time many types of living cell have been preserved successfully for long periods at low temperatures. It is found, however, that living cells do not necessarily survive indefinitely when their temperature is lowered to a level sufficient to reduce biochemical changes to a negligible value. The progressive loss of red blood-cells stored at − 78° C. has been reported [2], and at this temperature also ovarian tissue may fail to survive even one week, although under otherwise similar conditions it survived a year or more at − 190° C.[3]. It has been shown that most of the red blood-cells which do survive storage at −78° are not metabolically aged and behave normally on transfusion[4].

The damage suffered by red blood-cells during freezing and thawing whether in the presence of glycerol or not is closely correlated with the greatly increased concentration of electrolytes which occurs when water is removed as ice[5,6]. The exposure to concentrated salt solutions causes first an increase in the permeability of the cell membrane and finally complete dissolution of the cell. This appears to be due to the dispersion of lipids and lipoprotein from the cell membrane under the influence of the solvent action of concentrated salts. Glycerol protects against the immediately destructive action of freezing by reducing the concentration of salts in equilibrium with ice at a given temperature. If the proportion of molecules of glycerol to those of salt is sufficiently high, the concentration of electrolytes never reaches an immediately damaging level during freezing or thawing. The presence of glycerol does not, however, completely prevent the concentration of salts, and cells stored at low temperatures in the presence of glycerol are exposed continuously to relatively concentrated salt solutions. The possibility therefore arose that the observed rapid destruction of red blood-cells by concentrated salt, and the slow deterioration in less concentrated solutions were due to the same process operating at quantitatively different levels. It also seemed possible that the observed improvement in the survival of red blood-cells at 4° [7] and at − 20° [8] in media containing sodium citrate instead of sodium chloride was due to the lower solubility of the cell components in sodium citrate. These suggestions have received support from the observation that the survival of red blood-cells in the frozen state is much improved if the salt concentration of the suspending medium is kept as low as possible. This has been done either by increasing the concentration of glycerol[9,10] or decreasing the concentration of salt[11] in the suspending medium before freezing. More direct evidence comes from the chemical analyses of stored cells. Those kept in unfavourable media at temperatures between 0° and − 78° are found to have lost considerable quantities of their membrane components.

In the course of experiments designed to determine in greater detail the destructive processes occurring during the storage of red blood-cells at low temperatures, some observations of a more general interest have arisen—in particular, observations relevant to the structure and status of the cell membrane, and to the phenomenon of thermal shock, that is, the destruction of living cells which sometimes occurs on sudden chilling. There follows a preliminary account of these observations.

The experimental investigation of the decay of living cells stored at − 78° is necessarily slow. An attempt was therefore made to reproduce these changes above 0°. Red blood-cells were suspended in a medium kept unsaturated with respect to the components of their membranes. This was done either by repeated washing, or by including a neutral absorbent substance such as alumina in the suspending medium.

It was found that lipids and lipoprotein rapidly diffuse from red blood-cells suspended in fresh 0·16 *M* sodium chloride. After about 3 min. an equilibrium level of these components is reached and the loss from the cell falls to a low value. The equilibrium concentration of lipids and of lipoprotein in the suspending medium did not appear to represent a simple saturation of the medium with these substances. The concentration depended upon the previous treatment of the cells. It increased with the length of time the cells had been stored and decreased with the number of times they had been washed. With fresh cells washed five times in 0·16 *M* sodium chloride the concentration of lipids in the suspending medium is, normally, cholesterol 22, phospholipid 20, and lipoprotein (N) 18 μgm. per ml. If washing is repeated ten or more times the cells are reduced to a condition similar to that found after prolonged storage at low temperatures. There is loss of components from the cell sufficient to cause a volume reduction of 10–20 per cent. Cells in this condition do not hæmolyse more rapidly than fresh cells when suspended in 0·16 *M* sodium chloride; but if washing is further continued, lipids and lipoprotein are released into the suspending medium only in proportion to the fraction of cells which hæmolyse. It is almost as if a proportion of the cells were sacrificed to maintain a necessary minimum concentration of cell components in the suspending medium.

An even more convenient method of investigating the diffusion of components from the red blood-cell is to include a neutral absorbent with their suspension. In practice it is found that a rapid removal of lipids and lipoprotein, and slow progressive lysis take place if cells and chromatographic alumina are suspended together in 0·16 *M* sodium chloride in the proportion of 1 ml. of cells to 1 gm. of alumina. The results of a typical experiment are shown in Table 1. Using this technique it was possible to investigate the

Table 1. The Loss of Components from the Human Red Blood-cell when exposed to Alumina

Conditions	Quantities of membrane components from 1 ml. of red blood-cells remaining after various treatments (units: mgm. and ml.)					
	Cholesterol	Phospholipid	Lipid N	Volume	Hæmoglobin	Dry weight of lipids
Fresh cells	1·21	2·7	0·24	1·0	345	12
After 15 min. with 1 gm. alumina per ml. of cells at 37°	1·09	2·15	0·15	0·75	340	7
After 1 hr. at 37° in plasma	1·13	2·20	0·15	0·75	340	7
Lost from cells	0·12	0·55	0·09	0·25	5	5
Recovered from alumina	0·12	0·30	0·08	—	0	4·5

diffusion of various cell components and the rate of hæmolysis of the cells, at different temperatures. It was found that between 40° and 5° the rate of hæmolysis of cells in the presence of alumina decreased in a manner suggestive of a process governed by simple diffusion, that is, with an activation energy of 5,500 calories. At 4° the rate of hæmolysis began to increase as the temperature was further lowered, and at the lowest temperature so far investigated, − 5°, was still increasing. There was also, at temperatures below 4°, a decrease in the rate of diffusion of cholesterol and phospholipid from the cell. These results suggest a change in the state of the cell membrane at 4°. In this connexion it is particularly interesting to note that 4° is usually recommended as a better temperature for the routine storage of red blood-cells than 0°[13]. Another point of interest is that the effects of alumina, like those of washing, are strongly influenced by the past history of the cells. Cells stored ten days in 'acid citrate dextrose' plasma at + 4° hæmolyse in the presence of alumina twice as quickly as fresh cells.

Unlike the diffusion of superficial protein from the red blood-cell[13], the loss of lipoprotein does not appear to be simply reversible. Cells which have lost 40 per cent of their lipoprotein and 25 per cent of their volume are still in this condition after storing for one hour at 37° in a large volume of fresh plasma. On the other hand, P. L. Mollison, in a personal communication, reports that cells which have been washed seven times, and also a considerable proportion of cells withered by storage for long periods at low temperatures, survive normally on transfusion.

It is well recognized that the fluid contents of living cells are maintained at their normal levels by active processes against loss by diffusion. It is also recognized that damage can result at low temperatures from the greater reduction of metabolic activity as compared with diffusion[14]. The ability of the normal red blood-cell to synthesize cholesterol[15] and other membrane components[16] has been shown. This, together with the evidence above, suggests that not only the fluid contents but also the structure of the red blood-cell is maintained by a combination of synthesis and of passive diffusion from the plasma. So far as the red blood-cell is concerned, in the lease of life the tenant is responsible not only for interior decoration but also for structural repairs. The failure of the repair processes appears to be the first cause of death of red blood-cells during cold-storage in their normal medium.

It is important to note that the death of red blood-cells stored in plasma containing sodium citrate (acid citrate dextrose) at + 4° and also possibly in an equivalent medium with glycerol at − 22°[17] does not appear to be due to physical dissolution. Cells stored under these conditions do not, while alive, lose their membrane components, and those which survive do not live as long as normal cells when transfused. Thus, the physical breakdown of cells which occurs during cold storage in their normal media can be avoided by a suitable choice of storage conditions, at least until death occurs from other causes. The most suitable media for the storage of red blood-cells seem to be those in which the solubility of the cell components is least: namely, slightly acid media containing a salt, such as sodium citrate or acetate, the anion of which is more hydrated than the chloride ion.

Thermal Shock

The loss of lipids in an undiscriminating manner by simple diffusion appears to cause no great harm to the red blood-cell. In contrast, the loss of phospholipid selectively renders the cell metastable and subject to rapid lysis on cooling below 20°. The selective removal of phospholipid can be achieved practically by three methods. First, as is well

Table 2. The Loss of Components from Human Red Blood-cells following the various Treatments discussed in the Text

Treatment or storage conditions	Loss of cell components (per cent)					
	Cholesterol	Phospholipid	Lipid N	Volume	Hæmoglobin	
10 days at 0° in 0·16 *M* NaCl + 0·2 per cent glucose buffered to *p*H 7·0	23	22	46	—	5·0	Unfavourable storage conditions
14 weeks at −22° in 0·11 *M* sodium citrate + unbuffered 30 per cent glycerol	33	27	51	40	2·6	
1 year at −78° in 0·16 *M* NaCl + 15 per cent glycerol	17	22	29	20	6·0	
10 days at 0° in 'A.C.D.' plasma	5	7	0	0	1·0	Favourable storage conditions
14 weeks at −22° in 'A.C.D.' plasma + 30 per cent glycerol	0	0	0	0	1·8	
15 min. at 37° with 500 mgm. alumina per ml. of cells	14	16	36	17	1·0	Simulated unfavourable storage
20 washings at 37° in 0·16 *M* NaCl + 0·2 per cent glucose	15	15	29	13	2·7	
1 hr. at 0° in 1·03 *M* NaCl	9	26	12	—	1·7	Conditions causing sensitivity to thermal shock
1 hr. at 37° in 0·16 *M* NaCl containing 5·0 mgm. per ml. of detergent D_{14}	10	22	18	—	0·3	

known[18], by treatment with bacterial toxins, in particular, the toxin of *Cl. welchii*; secondly, by exposure to 1·0 *M* sodium chloride[6]; and thirdly, by means of selective absorbing substances, for example, certain anti-tubercular, macro-molecular detergents[19]. The effect of one of these substances, prepared by condensing *p*-tert-octyl-phenol formaldehyde resin with ethylene oxide, is shown in Table 2.

Some other living cells in their normal state show a similar sensitivity to cooling. This was first investigated with mammalian spermatozoa[20], and is usually referred to as thermal shock. An excellent review of this effect, which is found with a wide variety of living cells, has recently been written[21]. There is a considerable body of evidence to suggest that the lysis of red blood-cells which have lost some of their phospholipid, and the destruction of normal living cells by sudden cooling, are manifestations of the same general phenomenon. Thus, thermal shock with mammalian spermatozoa is reduced by treating the cells with lecithin before cooling[22]. It is increased if the cells are treated with the α toxin of *Cl. welchii* or with the macromolecular detergent described earlier. Conversely, red blood-cells which have been denuded of phospholipid can be protected against thermal shock if they are suspended in a medium containing lecithin.

The destructive effects of thermal shock take place with great rapidity. Red blood-cells rendered sensitive to thermal shock hæmolyse within 30 sec. if suddenly cooled from 37° to 0°. If they are returned to 37° after spending only one second at 0° they hæmolyse just as rapidly. Thus, the destructive effect of cooling takes place within one second, and may well be faster even than this.

The physical factors which appear to be important in the production of thermal shock are the temperature of the cell and change of temperature to which it is subjected. The rate of change of temperature if faster than 0·1 deg. per sec. and the gradient of temperature across the cell are relatively unimportant. The effect can occur at temperatures as low as − 30° [21]. There is therefore considerable circumstantial evidence to suggest that the effect results from some physical change in the cell membrane at low temperatures.

The change in the chemical structure of the cell which confers sensitivity to thermal shock appears to be an increase in the ratio of cholesterol, or possibly the cholesterol lipoprotein complex, to lecithin in the cell membrane. The alteration of this ratio either by removing lecithin or by adding cholesterol increases the sensitivity to thermal shock. The absolute amounts of these lipids are relatively unimportant.

The observations upon the breakdown of red blood-cells by diffusion and by thermal shock provide some evidence concerning the status of the components of the cell membrane. They suggest that some of the phospholipid and cholesterol of the cell are free to diffuse reversibly, and that lipoprotein is free to diffuse away from the cell but does not return by the same route.

The classical view of the structure of the red blood-cell membrane implies a framework of stroma surrounded by a bimolecular layer of lipids, with a sprinkling of antigenic and antisphering protein at the surface. It seems unlikely that a cell possessing such a structure could lose a substantial portion of its membrane components and yet remain intact. Among more recent views upon the architecture of human red blood-cells are two which agree quite well with the experimental results outlined above. The first[23] suggests a membrane composed of lipoprotein the concentration and orientation of which diminish radially inwards. The second[24] envisages a membrane composed principally of fibrils, of a lipoprotein called elinin arranged parallel to the cell surface and cemented together by ether-soluble lipids. The idea that the lipoprotein of the cell membrane is held at a preferred orientation fits harmoniously with the observed irreversible nature of its diffusion. If the cell membrane is relatively thick, as recently proposed[25], some loss of its components could presumably be borne without the destruction of its function as a permeability barrier. The observed volume changes are also in good agreement with those of a hypothetical cell with a thick membrane composed of a 2 per cent lipoprotein gel.

The orientated lipoprotein of the cell membrane is thought to be cemented together by ether-soluble lipids[24]. If this hypothesis is accepted, it provides grounds for an attractive speculation concerning the mechanism of thermal shock. If the cement is made from a mixture rich in cholesterol, it is likely to be brittle at low temperatures. The mechanical stresses resulting from a change in temperature could then cause the cement to fracture, and destroy the permeability properties of the membrane. Whatever is the true function of the various components of the cell membrane, the physical factors upon which thermal shock is observed to depend make it probable that the phenomenon depends upon some mechanical failure at least similar to that suggested.

The experimental results reported in this paper form the subject of a more detailed account which will be published later.

I am indebted to Dr. A. S. Parkes for his interest and advice. My thanks are also due to Dr. P. L. Mollison for making freely available the results of his investigations, and for supplying samples of frozen and stored blood. I also wish to acknowledge the skilful assistance of Miss G. O. McMahon.

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OBITUARY

Sir John Myres, O.B.E., F.B.A.

Sir John Myres, emeritus professor of ancient history in the University of Oxford, died peacefully on March 6, at his home in Oxford, aged eighty-four. The world of scholarship and his many friends will feel a grievous sense of loss.

Few, if any, in the past half-century strove more devotedly and clear-sightedly than he in the allied fields of archæology and anthropology, not only in a great output of influential books and articles, but also in vigorous executive action. As a geologist and a geographer, too, he held an honoured place. His broad humanism, capacity for intensely hard work, and expressive prose style which clarified difficult subjects with wit as well as wisdom, were the inheritance from the confident, all-inquiring era of the later nineteenth century. The bold sweep of such wide humanism, unafraid of the great problems which humanity has to face, but not pedantic, without dogmatic ideology, and founded firmly on fact, is more needed to-day than ever.

A scholar of Winchester and of New College, Oxford, his gifted versatility was evident from the start. In 1892 he won a Craven fellowship for classical studies in Greece, and also the Burdett-Coutts scholarship in geology. It is not possible to enumerate all the distinctions which followed throughout a long life, lived to the last with outstanding energy, courage and cheerfulness. He was a Student of Christ Church during 1895–1907, and then was elected professor of Greek in the University of Liverpool. In 1910 he returned to Oxford as Wykeham professor of ancient history, and held the chair until 1939. During 1919–32 he was general secretary of the British Association, a vice-president of the Society of Antiquaries from 1924 until 1927 and gold medallist in 1942, a past-president of the Royal Anthropological Institute, Victoria medallist of the Royal Geographical Society and chairman of the British School at Athens during 1934–37. He was honoured by doctorates from the Universities of Wales, Manchester, the Witwatersrand and Athens.

His adventurous career as a lieutenant-commander and later commander (R.N.V.R.) in the Aegean during the First World War has an almost legendary fame, in the Minoan and Homeric tradition. For his exploits, notably against the Turkish coastal garrisons, he was made a Commander of the Royal Order of George I of Greece. He received his knighthood in 1943.

Where others would have relaxed their efforts, Sir John Myres redoubled his. The last three books he wrote, "Scripta Minoa II", "Geographical History in Greek Lands" and "Herodotus: Father of History", all appeared after his eightieth birthday (which had been celebrated by a special number of the journal *Man*).

Methods and aims in education in schools and universities interested him greatly, and his combination of imagination with shrewd common sense gave his colleagues many a lead to follow. His practical qualities shone in administration, and to him goes a large measure of the credit for initiating International Congresses in Prehistoric and in Anthropological Studies, which now meet at regular intervals.

His aim was to encourage people to think for themselves, and think clearly. His personal preference was for difficult problems which went to the heart of human history and action, as shown in his famous volume "Who Were the Greeks?". But it was perhaps in personal contacts that he exerted his greatest influence. He was always accessible, helpful, frank; and especially ready to encourage young men. To visit him and discuss one's work was inspiring, for he had a truly noble mind, and one never departed without several valuable new ideas that had been good-naturedly suggested.

Those who had the privilege of knowing him—and they are scattered all over the world—understood how greatly he was sustained, especially in the infirmities of his later years, by the devoted care of Lady Myres. His surviving son, Mr. J. N. L. Myres, is Bodley's Librarian.

John Bradford

NEWS and VIEWS

Agriculture in Great Britain: Sir James Scott Watson

Sir James Scott Watson, chief scientific and agricultural adviser to the Ministry of Agriculture and director general of the National Agricultural Advisory Service, is retiring on December 31 next, shortly after his sixty-fifth birthday. After graduation at Edinburgh and advanced study in Berlin and at the Iowa State College, he joined the agricultural staff at his old University. During the First World War he served with the Royal Field Artillery in France. During 1922–25 he was professor of agriculture and rural economy at Edinburgh, going thence to the Sibthorpian chair of rural economy at Oxford, which he occupied until 1944. The Second World War took him away from academic life, his important duties including membership of the Scientific Food Committee and during 1942–44 the post of agricultural attaché at the British Embassy, Washington. Returning, he became chief education and advisory officer in the Ministry of Agriculture, and in 1948 moved to the post he is about to relinquish. Sir James's exceptionally wide and profound range of agricultural knowledge in the detail of practice, in the applications of science, in history and in national economic aspects, have made him for many years an outstanding authority. His ease and clarity as a writer have enriched the literature with many papers and some excellent books including the famous "Agriculture: the Science and Practice of British Farming", everywhere known as "Watson and More". Broadcast talks, lectures and official work have made him widely known and greatly respected among farmers, and his editorship of the *Journal of the Royal Agricultural Society* from 1931 until 1945 widened still further his influence on agricultural teaching and thought. To him, as its first head, fell the launching of the National Agricultural Advisory Service, instituted in 1946. He is a member of the Agricultural Research Council and was knighted in 1949.

Prof. H. G. Sanders

Prof. H. G. Sanders, who is to succeed Sir James Scott Watson as chief agricultural and scientific

adviser to the Ministry of Agriculture, was born in 1898 and is at present professor of agriculture at Reading. From Wellingborough School he joined the Royal Field Artillery in 1917, served in France and on demobilization went up to St. John's College, Cambridge, where he studied agriculture. Interest in experimental husbandry drew him away after a short spell of practical farming, and during 1922–29 he was on the staff of the Animal Nutrition Institute (then in Cambridge) engaged on statistical analyses of lactation phenomena and other cattle physiology topics. Turning then, with great success, to the teaching of crop husbandry, he became a University lecturer in the School of Agriculture, Cambridge, filling that position until 1944, when he was elected to the professorship at Reading. In fruitful partnership with Mr. F. H. Garner, he completed well-known field-experiments on plant populations and yield in potatoes, cereals and sugar beet, on cultivations and in the then novel use of grass and lucerne mixtures. He was elected to a fellowship at St. John's in 1944 and in 1939 published "An Outline of Crop Husbandry", still a standard text. As executive officer of the Hertfordshire War Agricultural Executive Committee, 1941–44, he achieved notable success in the stiff war-time tasks of the county. In the Agricultural Improvement Council of England and Wales he has played a leading part in developing the regional husbandry experimental farms supported by the Ministry. He is a member of the University Grants Committee. Both academic and farming circles will welcome the appointment.

Pathology at Sheffield : Dr. D. H. Collins, O.B.E.

Dr. D. H. Collins, reader in clinical pathology in the University of Leeds, has been appointed to the chair of pathology in the University of Sheffield in succession to Prof. H. N. Green, who has taken up the chair of experimental pathology in the University of Leeds (see *Nature*, December 5, p. 1028). Dr. Collins was educated at Rossall School and the University of Liverpool, where he graduated in medicine in 1930, taking his M.D. three years later. In 1934, after various hospital and university appointments in Liverpool, he became the first Rheumatism Research Fellow in the University of Leeds and held this fellowship until the outbreak of the Second World War, when for the next seven years he was seconded to the Emergency Pathological Service. After establishing a base-hospital laboratory at Scotton Banks Sanatorium, Dr. Collins went to Sheffield in May 1940 as pathologist to Wharncliffe Emergency Hospital, later becoming medical superintendent of the Hospital in charge both of its pathological services and its medical administration. In October 1946 he returned to the University of Leeds as reader in clinical pathology. Apart from his work on a number of medical advisory committees and being an assistant editor of the *Journal of Pathology and Bacteriology*, Dr. Collins's main research interests are centred on disease of the bone, and he is the author of the book "The Pathology of Articular and Spinal Diseases".

Civil Engineering at University College, Swansea : Dr. B. G. Neal

Considerable developments have taken place during recent years in the School of Engineering at Swansea under the direction of Prof. L. J. Kastner. Opportunity has now been taken to institute a chair in civil engineering, and the first professor of this subject will be Dr. B. G. Neal, who will take up his appointment on October 1 next. Dr. Neal obtained first-class honours in the Mechanical Science Tripos at Cambridge in 1942, being awarded the Rex Moir, Ricardo and John Bernard Selly Prizes. For the next three years, as a temporary experimental officer, he was concerned with naval aircraft work, and in 1945 represented the Department of Scientific and Industrial Research at the Underwater Ballistics Conference in Washington. A later period in the United States was spent on research on plastic theory at Brown University, R.I., under Prof. W. Prager. Apart from this, his research work has been at Cambridge, where he is a Fellow of Trinity Hall and lecturer in engineering. A paper on the lateral instability of yielded mild steel beams was published by the Royal Society. Publications on framed structures under repeated loading gained for Dr. Neal and his collaborator the Manby Premium and the Telford Premium of the Institution of Civil Engineers, and he is at present completing a book on analytical methods of plastic theory.

Abbreviation of Bacterial Generic Names

When using the binomial system of nomenclature, bacteriologists often contract or abbreviate the generic name ; there are no rules to guide them, and each author may create his own shortened form. What form appears in print depends on the editorial policy of the particular journal, and in this there does not seem to be a common practice. The abbreviations used in the "World List of Scientific Periodicals" are based on the general and special rules of the International Code of Abbreviations for Titles of Periodicals, but similar rules do not exist for the generic names of bacteria. The Bacteriological Code of Nomenclature does not recognize the abbreviation of generic names, which seems to be a labour- or space-saving device resorted to by authors and editors. A preliminary inquiry is being made to find out if there is a demand from editors for the standardization of these abbreviations, and it is hoped to collect information on the present policy of certain journals published in the English language, some of which use single-letter abbreviations and others use rather longer forms. The inquiry was started in relation to the abbreviation of generic names of bacteria, but other points have been raised by individual editors. Those who hold views on this and related subjects are asked to get in touch with Dr. S. T. Cowan, the joint secretary (representing medical bacteriology) of the International Committee on Bacteriological Nomenclature, at the National Collection of Type Cultures, Colindale Avenue, London, N.W.9.

Figuring of Types in Entomology

At a meeting of the International Union of Biological Sciences, held at Nice during August 1953, a type-figuring sub-section of the Entomology Section was formed, and its activities are now directed by a committee of fifteen under the chairmanship of Mr. N. D. Riley, keeper in the Department of Entomology, British Museum (Natural History), London. The objective of the sub-section is to make as readily available as possible information on types of insects and other animals, especially by distributing figures of the type specimens, to assist in research work and to have some information available in case types are accidentally destroyed. It is proposed to collect in a central file negatives of photographs of type speci-

mens, or of photographs of drawings or other illustrations of type specimens or of their parts; to catalogue these and make lists available from time to time; to make and to distribute prints of the photographs for suitable fees to those requesting them; and, when finances permit, to make or arrange to have made illustrations of types for the central file. The sub-section is run on a non-profit basis, and in fact will operate at a financial loss until receipts from the sale of prints cover expenses or until grants are obtained. The chief need at the moment is for negatives or other illustrations for the central file, unpublished illustrations being, of course, the most desirable. At present the headquarters of the sub-section and the central file are in Ottawa, and all correspondence should be addressed to Mr. P. F. Bruggemann, Curator, c/o Division of Entomology, Science Service Building, Ottawa, Ontario.

A Faked Fossil

In the *Museums Journal*, March 1954, Mr. H. F. Whitworth, of the Geological and Mining Museum, Sydney, exposes the faked nature of an insect wing in a specimen of selenite. Presented to the Museum in 1912, this was examined by Dr. R. J. Tillyard, who with some hesitation was eventually convinced of the genuineness of the 'fossil' and stated that it belonged to the Tertiary age and was unlike any living form. He placed it within the family Tettigoniidae and named it *Austrodictya corbouldi*. Recently, the specimen has been re-examined and it was seen that the crystal of selenite has been opened by a knife, the wing inserted and the edge of the crystal pounded in an endeavour to hide the crack produced. Experiments showed that the flexible nature of selenite allowed this operation to be carried out easily. The wing has now been identified as the forewing of *Terpandrus horridus*, a present-day form, commonly known as the great gum-tree grasshopper.

Latin American Research in Parasitology

The third report in the series, "Latin American Contributions to Scientific Progress", is entitled "Parasitology 1949–50" (pp. 287; Montevideo: Unesco Science Co-operation Office for Latin America, 1953), the two previous publications being concerned with chemistry and with mathematics, respectively. The object of the series is to make known to a much wider public than at present the contributions that Latin American scientific workers are making in various fields. The present report, which is by Prof. J. E. Mackinnon, in collaboration with Prof. S. B. Pessôa, Prof. F. Pifano and Dr. A. Trejos, is concerned with the publications in the field of parasitology that appeared during the years 1949–50. Parasitology is a field that has close association with other studies such as pathology, hygiene, etc.; but while clinical and surgical references appear in the bibliography, the reviews themselves are concerned almost exclusively with experimental and descriptive parasitology, although a certain amount of attention is given to epidemiology and prophylaxis since they are closely related to the biology of the parasite. The reviews are divided into a series of chapters under the five headings protozoa, helminths, arthropods, fungi and various, occupying pp. 14–250, and the bibliography occupies the remaining thirty-seven pages. There are about eleven hundred references, and from this bibliography the titles of the publications, the names of the workers and their fields of study can be found, all of which is most useful information. The authors are Latin Americans or come from other countries but live and work in institutions in Latin America. Naturally, some publications of importance to Latin America come from European possessions or from Panama, and these have been dealt with in their appropriate places by footnotes and do not appear in the body of the text or in the bibliography. On the whole, the English is good; but there are some slips: for example, "flyes" as the plural of fly, "on account of" instead of "as shown by" and so on.

Diploma in Health Education

One of the greatest handicaps to health education has been the lack of properly qualified people. It is hoped that this weakness will be remedied by the proposal of the Institute of Education (University of London) to offer a comprehensive course in health education. It is intended to give a professional training to doctors, nurses, teachers and others with suitable experience, in the basic disciplines and practice of health education. The course will last a year and lead to a diploma of the Institute. The syllabus will deal with the principles of education; principles of social and preventive medicine, including epidemiology and vital statistics; the history and administration of public health and of education; the scientific bases of health and human behaviour with particular emphasis on heredity and genetics, growth and development, environmental hygiene, and the general principles of the causation, spread and prevention of infective disease; and the principles, methods and media of health education. Field-work will form a part of the course and visits will be made to illustrate the work of hospitals, clinics, local health authorities, schools, youth clubs and industrial concerns.

From the content of the course it would seem that students who obtain the diploma will be qualified to plan and administer comprehensive health education programmes, as well as having the practical experience of the health teacher. A feature of particular interest is the opportunity of providing a tailor-made syllabus for each student to ensure that those with a medical background devote more time to studying education, and vice versa. Sponsors of the course are the London School of Hygiene and Tropical Medicine, the Institute of Child Health and the Central Council for Health Education.

Auxin and Mushroom Growth

I. M. Fraser (*Austral. J. Biol. Sci.*, **6**, 379; 1953) reports that the cultivated mushroom, *Psalliota hortensis*, var. *albida*, was unable to grow appreciably on a liquid medium containing only glucose, asparagine and mineral salts. Growth was slightly increased by additions of thiamin and biotin to this medium; but a number of other vitamins were without effect. Indole-3-acetic acid, however, in concentrations of 5–100 mgm./l., produced a very notable increase in growth, particularly with biotin and thiamin present, but only in surface culture. The growth of both floating and submerged inocula was markedly increased by additions of yeast extract, cotton wool extract, or mushroom compost extract, although these did not appear to contain appreciable quantities of indole-3-acetic acid. The fungus grew fairly well on basal medium solidified with agar which had been purified to remove vitamins. Addition of thiamin or biotin did not promote growth. Concentrations of indole-3-acetic acid of 10 and 100 mgm./l. almost completely prevented initial growth,

while concentrations of 0·001, 0·1 and 1·0 mgm./l. were without effect. However, after about thirty days, vigorous growth commenced in the medium originally containing 10 mgm./l. indole-3-acetic acid and proceeded at the same rate as in its absence. It seems probable that this was due to inactivation of the indole-3-acetic acid by the small amount of mycelium formed. It is suggested that indole-3-acetic acid may play a part in the growth processes of this fungus similar to that in higher plants, although the possibility that some related substance such as tryptophan is required for growth must also be considered, particularly in view of the unidentified growth-promoting factor present in various extracts.

Dissemination of Rust Fungi in India

In Scientific Monograph No. 18, published in 1952 by the Indian Council for Agricultural Research, Prof. Mehta, of Agra College, has presented a detailed account of a study of the dissemination in India of three rusts of wheat and barley, *Puccinia graminis tritici*, *P. triticina* and *P. glumarum*. The work was carried out mainly between the years 1932 and 1938 and is a continuation of that reported earlier in Monograph No. 14. By means of slide traps on stationary aeroscopes or on kites, balloons or aeroplanes in the vicinity of some twenty stations throughout the country, Prof. Mehta has compiled estimates of the aerial distribution of the fungi and related these data to the trajectories of relevant winds and the incidence of disease outbreaks. The results, presented as a series of maps and tables in the monograph, showed that spore showers preceded outbreaks of rust at most stations and that winds usually came from places where the diseases had been prevalent from fifteen days to two months previously. Such sources of inoculum usually originated in the hills, where an early crop was sometimes grown or developed from tillers or self-sown plants, becoming infected earlier than that in the plains. These findings are discussed and the conclusion reached that the most important foci for the dissemination of rust inoculum lie in central Nepal, the Nilgiris and the Palni hills, and that early spread from these regions to the Indo-Gangetic plain and Peninsular India, respectively, is chiefly responsible for outbreaks experienced there. In a final section the author briefly reviews the situation and makes proposals for the control of these rusts in India. Measures recommended for specified hill regions include suspension of the early crops of wheat and barley, destruction of self-sown plants and stray tillers between seasons and postponement of sowing to coincide with that in the plains.

Graphs of the Compton Energy–Angle and the Klein–Nishina Formula

Circular 542 of the National Bureau of Standards, Washington, D.C., is primarily a representation in graphical form, by Ann T. Nelms, of the Compton energy–angle relationship and the differential and integral Klein–Nishina cross-sections as functions of the energy and direction of the scattered photon and of the recoil electron (pp. iv+89. Washington: Government Printing Office, 1953; 55 cents). Unpolarized primary gamma-rays in the energy-range 10 keV.–500 MeV. are considered. It is stated that interpolated values may be obtained from the curves with an accuracy of 2 per cent. The data are expressed in the units used most often by experimentalists and are based on DuMond and Cohen's (1951) values of the fundamental constants. The graphs are preceded by a discussion of the various experimental, theoretical and mathematical considerations involved in the relationships finally chosen for computation and representation. The Circular represents the fourth item in a series of surveys and tabulation of information on radiation physics carried out with the support of the Biophysics Branch of the United States Atomic Energy Commission. The three previous items have been given limited circulation.

Webster Plass Collection of African Art

The late Mr. Webster Plass, of Philadelphia, and his wife collected for many years examples of African works of art. Mr. Plass always wished that his collection would eventually find a permanent home in the British Museum, and Mr. William Fagg, assistant keeper in the Department of Ethnography, has now compiled a memorial catalogue of the collection. Bearing the title "Webster Plass Collection of African Art" and the sub-title "Catalogue of a Memorial Exhibition held in the King Edward VII Galleries of the British Museum", this catalogue has been published by the British Museum, the cost having been borne by Mrs. Plass (pp. 47+46 plates; 1953). There are forty-six pages of illustrations of works of art made by various Central and West African peoples, and these are described in detail in the catalogue. There is also a map showing the distribution of their makers. The whole is well and clearly set out, and Mr. Fagg is to be congratulated on his work. It is a pity, perhaps, that the paper on which the half-tones are printed could not have been of a rather better quality. The reproductions are good but could have been even better. There is a short introduction on African art in general.

Stanford University Natural History Museum

The main fish and herpetological collection rooms of the Natural History Museum of Stanford University have recently been entirely refitted at a total cost of 30,000 dollars, 93 per cent being raised by a graduate students' Zoology Project Fund to which many graduates and friends of the University have contributed. The fish collections have been supplied with 9,000 sq. ft. of new steel-shelving which will increase the fish research space by two-thirds. Modern lighting has been installed and also a new electric 'dumb waiter' to connect the double-decked fish collection with other floors in the building, so that the Stanford collection, which contains about 750,000 specimens, is now one of the best-housed in the world. It has also been possible to utilize the old shelving for renovating the herpetological collection facilities, thus increasing their shelf-space by 100 per cent.

Industrial Relations and Human Relations

In an address on January 20, 1954, to the Birmingham branch of the Institute of Personnel Management, Sir Godfrey Ince, permanent secretary to the Ministry of Labour and National Service, concluded that although we have gone a long way towards establishing good industrial relations and constitutionalism in British industry and have made great progress in good labour relations techniques, "we have not yet gone very far in tackling the problem underlying good human relations, the problem of securing the right attitude of mind in industry". The address is printed in the latest issue of the Institute's journal, which also contains an important article on joint

consultation in the electricity supply industry by R. D. V. Roberts, secretary to the National Joint Advisory Council for the Electricity Supply Industry (**36**, No. 327 ; March 1954). A report of a discussion on the value of wages as an incentive to higher production is also included.

The National Trust

The fifty-eighth annual report of the National Trust, for the year 1952–53, gives a further warning of the importance of increased voluntary support to enable the Trust to take advantage of the new opportunities which the Historic Buildings and Ancient Monuments Act offers it. This Act embodies a good many suggestions made to the Government by the Trust, and the Council notes with particular satisfaction that the Act not only allows grants to be made from the Land Fund to acquire historic buildings but also permits annual grants for maintenance, including assistance in the case of inhabited houses in private ownership. Although the deficit of the Trust on maintenance and administration in 1952 was no more than £29,000 on an income of £355,000, and its membership rose during the year from 28,365 to 40,300, the Jubilee Fund raised in 1947 is now exhausted as well as most of the special reserves ; it has been necessary to impose a temporary standstill on all but essential improvements, and only the most urgent repairs and decorations can be carried out from general funds. This naturally limits the properties which the Trust is able to accept for preservation, in the absence of provision for endowment ; and a large increase in the subscription income is desirable if the Trust is to continue to carry on and expand its work.

Progress

An excellent example of the magazines which are being produced by the larger industrial undertakings both for the information of their own employees and the enlightenment of others is shown by the present issue of *Progress*, the journal of Unilever, Ltd. (**43**, No. 241 ; 1953–54). Prof. G. J. Renier contributes a factually imaginative discourse on Anglo–Dutch amity (Unilever has strong Dutch associations), while other articles deal with places important in the Unilever economy, like the Belgian Congo and other parts of West Africa. A fascinating and unusual article on trade marks and their protection is contributed by L. A. Elwood, while other articles deal with such topics as colour in the factory and recent developments in industrial welfare in Norway. Ronald Brech explains as lucidly as possible the meaning and purpose of the bank rate, and Dr. Eric Ashby describes the need for co-operation between the universities and industry in the selection and training of potential managerial recruits. The final article shows the way in which the Department of Scientific and Industrial Research serves the community not merely through industry but more directly as a source of knowledge to make more widely known the decisions of government. The journal is produced in exquisite taste, the cover being made up of two water colours by the Belgian artist, Prof. Maurice Van Essche, who is said to be one of the few European painters who have understood and been able to interpret the character of Africa.

Manchester Public Libraries : Report for 1952–53

The report of the City of Manchester Public Libraries Committee for the year 1952–53 (pp. 36+ 8 plates) records an increase in total issues to readers from 5,937,230 to 6,241,375. This was due partly to the opening in May 1952 of the first specially designed library in Wythenshawe, already the third busiest library in the city. Of this figure, as the City Librarian notes in his report, 1,003,644 issues were to children, but books consulted in the reference libraries also increased, from 676,469 to 719,361, with an increase in readers from 555,455 to 602,528. The number of volumes in the reference libraries increased from 418,328 in 1952 to 425,484 in 1953 ; of these, 55,777 volumes were in the technical library, compared with 54,100. Additions to the stock of the libraries totalled 83,727, withdrawals amounting to 80,554, and the City Librarian directs attention to the effect of the increasing cost of books : while for the three years 1948–49, 1951–52 and 1952–53 the numbers of volumes purchased were respectively 92,466, 93,593 and 80,522, there being a noticeable reduction in the most recent figure, the corresponding expenditure has been £31,898, £36,331 and £36,693, the average price per book being respectively 6·89*s*., 7·78*s*. and 9·11*s*. Moreover, in the Reference Library the average cost is now 28·49*s*. and in the Technical Library 29·18*s*. While the book fund has slightly increased, the newspapers and periodicals fund has lagged much further behind rising costs ; in 1952 this amounted to no more than £2,899, an increase of £55 since 1921, and, of fifty-eight titles of science periodicals listed by the Science Museum Library in London as not available for loan to other libraries, only eighteen were available in the Manchester Public Libraries. These rising costs obviously hamper the extension of the Technical Library service, and hope is expressed that speedy government aid will be forthcoming : "for it is within the power of the public library service of this country to provide industry with an information service which would repay handsomely any expenditure involved". During April 1952 the department acquired an 'Agoflex' copying machine which renders possible a 'while-you-wait' copying service : 5,675 items have been copied in this way, compared with 2,089 last year. Some 503 books and periodicals were loaned specially to local firms, an increase of 40 per cent on the previous year, and stress is laid on the growth of co-operation with the industrial libraries of the area, the library of the Manchester College of Technology and other local and national libraries.

New Laboratory for Oceanographic Research at Woods Hole

The United States Navy has built a new laboratory for oceanographic research at Woods Hole, Massachusetts, and the laboratory will be formally opened on June 21. Following this, during June 22–24, the United States Office of Naval Research, in conjunction with the National Academy of Sciences and the National Research Council, will hold a three-day oceanographic convocation, in which will be presented the broad scientific significance of oceanography, its needs and its potentialities, and its relations to the constituent fields of science. The first day will be devoted to physical oceanography, the second to biology in oceanography and the third to geology, geophysics and meteorology in oceanography. Some twenty scientific workers, drawn from both the United States and abroad and representing a wide field of interests, are being invited to participate. The proceedings will afterwards be published.

Pan Indian Ocean Science Association : Congress in Perth, Western Australia

THE second science congress of the Pan Indian Ocean Science Association will be held in Perth in the University of Western Australia during August 17–24, under the presidency of Prof. H. J. Bhabha. The Association, which was formed in January 1951 at a meeting in Bangalore, exists to discuss and promote concerted action in regard to scientific problems affecting the peoples and countries around the Indian Ocean and generally to improve friendship and co-operation among them. Representatives are sent from Australia, Burma, Ceylon, France, India, Madagascar, Malaya, Netherlands and Portugal. Those attending the congress will be in one of three categories: official delegates of each participating country, the limit being ten per country; accredited members, who are nominated by the representative institution of the member country; and guests invited by the president. The work of the congress will be for the most part arranged by the seven sections of the Association: (*A*) physical sciences; (*B*) biological sciences; (*C*) geological sciences; (*D*) agricultural sciences; (*E*), economics, education and social sciences; (*F*) geography and oceanography; and (*G*) human ecology. During August 25–28 a number of excursions will be made, catering mainly for those concerned with the biological sciences; geology and mining; and agricultural sciences and forestry. All communications relating to the congress should be addressed to Prof. A. D. Ross, Honorary Secretary, P.I.O.S.A., 31 Ventnor Avenue, West Perth, Western Australia.

Vacuum Techniques : Symposium in the United States

A SYMPOSIUM on high vacua, organized by the Committee on Vacuum Techniques, will be held at the Berkeley Cartaret Hotel, Asbury Park, New Jersey, during June 16–18, 1954. The papers to be read will deal with the following five topics: a panel on nomenclature and standards; new equipment and instruments; fundamental developments in vacuum technology; methods and techniques; and applications and processes. The Committee on Vacuum Techniques has been organized as a non-profit corporation, with the prime purpose of sponsoring the symposium; in addition, it hopes to further the dissemination of knowledge of high vacuum techniques and to assist in the establishment of universally acceptable nomenclature and standards. All individuals and companies interested in attending the symposium, presenting papers or participating in other activities of the Committee should write to the Committee at P.O. Box 1282, Boston, Mass.

Chemical Society : Officers

OFFICERS of the Chemical Society have been elected as follows: *President*, Prof. W. Wardlaw; *Vice-Presidents*, Sir Ian Heilbron, Sir Cyril Hinshelwood, Prof. C. K. Ingold, Dr. W. H. Mills, Sir Eric Rideal, Sir Robert Robinson, Prof. R. D. Haworth, Prof. E. L. Hirst, Prof. E. R. H. Jones, Prof. R. P. Linstead, Prof. W. H. Melville and Sir John Simonsen; *Treasurer*, Mr. M. W. Perrin; *Secretaries*, Prof. H. Burton, Prof. E. D. Hughes and Dr. L. E. Sutton; *New Members of Council*, Dr. C. C. Addison, Dr. V. C. Barry, Dr. E. J. Bourne, Dr. E. A. Braude, Dr. H. M. N. H. Irving, Prof. J. M. Robertson, Prof. H. N. Rydon and Prof. H. D. Springall.

Announcements

PROF. T. H. MARSHALL, professor of social institutions in the London School of Economics and Political Science, has been appointed to the Martin White chair of sociology tenable at that School. The title of reader in education in the University of London has been conferred on Mr. A. C. F. Beales in respect of the post held by him in King's College.

THE bequests recently made to the University of Sheffield under the wills of the late Sir George Franklin, who died in 1916, and Miss Daisy Franklin, who died in 1948, will be used for the endowment of the full-time chair of medicine in the University, which will henceforth be known as the Sir George Franklin chair of medicine. Sir George Franklin was pro-chancellor and chairman of council of the University during 1905–16.

THE second annual meeting of Committee *E*-14 on Mass Spectrometry, of the American Society for Testing Materials, will be held during the week beginning May 24 at the Jung Hotel, New Orleans, Louisiana. Forty-six papers will be presented, covering isotopic abundance determinations, ionization potentials, solids analysis, high molecular-weight analysis, and new mass-spectrometer techniques and developments. During the week the election of new officers of the *E*-14 Committee will be made. Further details can be obtained from Mr. William Priestley, jun., Standard Oil Development Co., P.O. Box 121, Linden, New Jersey.

THE annual Cornell University summer laboratory course in techniques and applications of the electron microscope will be given during June 14–26 in the Laboratory of Electron Microscopy, Department of Engineering Physics, under the direction of Dr. Benjamin M. Siegel. The course is designed for research workers in academic institutions or industry who have recently entered the field of electron microscopy or who are now planning to undertake research problems involving applications of this instrument. Inquiries should be addressed to Dr. Siegel at the Department of Engineering Physics, Rockefeller Hall, Cornell University, Ithaca, New York.

THE Textile Institute is offering a Cotton Industry War Memorial Scholarship, of maximum value £950, for a three-year course in textile technology at an advanced level, with provision for industrial training and experience of a special character in Britain or overseas. The closing date for applications is April 30. The Institute is also offering a Peter Coats Scholarship, of maximum value £200, for one year of full-time study preparatory to taking up a course in textile technology at a university or college. The closing date for applications is May 31. Candidates for both these awards must be male British nationals less than twenty-four years of age. Application forms and further details can be obtained from the General Secretary, Textile Institute, 10 Blackfriars Street, Manchester 3.

THE second general assembly of the Italian Geophysical and Meteorological Society will be held in Genoa during April 23–25. The first two days will be devoted to the reading of twenty-three papers, and the final day will be reserved for the discussion of the Society's affairs and an excursion. Further information can be obtained from the Società Italiana di Geofisica e Meteorologia, via Balbi 5, Genova.

MEDICAL USES OF ATOMIC ENERGY*

RADIOACTIVE isotopes, which are produced by neutron irradiation in atomic piles, or extracted from the waste products of nuclear fission, or derived from the bombardment of targets in the cyclotron, are influencing many aspects of medical research and certain forms of treatment. Their peculiar merit is that, while undergoing exactly the same metabolism as ordinary matter, they can be traced through the body with great sensitivity, using suitable instruments, or, when larger amounts are employed, useful radiation effects can be caused in certain parts of the body.

The high sensitivity of detection of radioactive isotopes makes it possible to observe the dynamics of many physiological processes without disturbing the equilibria being measured. Radioactive iron, for example, is used for determining whether a particular type of anæmia is due to the failure of the iron to be absorbed from the diet, or to the iron being absorbed but not properly used in the hæmoglobin and the red cells. More complex chemical compounds, or even organic structures, are 'labelled' with radioactive atoms and their metabolism studied. Thus, penicillin can be made containing a radioactive sulphur atom, or vitamin B_{12} with radioactive cobalt, or blood cells with radioactive chromium. The problems studied with such labelled compounds include the formation of bones, abnormalities of salt excretion in adrenal diseases, the mechanism of conduction of impulses along nerves, the formation and repair of teeth, the function of the thyroid, and the metabolism in the body of steroid, peptide and carbohydrate molecules. In most of these fields the skilful use of radioactive isotopes yields information which could not otherwise have been obtained.

Measurements on patients are not limited to tests depending on the removing of body fluids; they can also be made *in situ* and are of much value to the surgeon in the operating theatre. In fractures of the head of the femur the question of whether the blood supply has or has not been abolished can be answered by injecting radiophosphorus a few hours before the operation and measuring its relative concentrations in the head and shaft of the bone. Radiophosphorus is also used during operations on brain tumours to indicate the extent of operation necessary. By intravenously injecting small amounts of radiosodium solution and measuring the activity with counters placed on the skin, the velocity of the blood flow in the veins can be measured in conditions where thrombosis is likely to occur. The same method can be employed in measuring the speed of blood circulation around the whole body, or through the lungs alone. The dosages used in these investigations are so small that the irradiation received by the body during any of these tests is less than that received in ordinary X-ray examinations.

Turning to the use of radioactive isotopes in treatment, the aim is to deliver the maximum dose to the places to be destroyed with the minimum dose anywhere else. In one type of treatment the isotopes are applied externally or into body cavities. Thus, skin lesions are treated by applications of sheets of plastic impregnated with radiophosphorus. Cancers involving the bladder lining can be treated with a solution of radiobromine contained in a distensible bag which can be inserted into the bladder. If a suitable colloid is introduced into a cavity in the body it will diffuse out only very slowly, if at all. The linings of the abdomen and of the chest may become involved with growth, causing distension of these cavities with fluid; the surface layers of such growth may be selectively irradiated by the introduction of a colloidal suspension of radioactive gold into the cavity.

Quite a different technique is to inject colloidal gold particles of appropriate size into the bloodstream, which will carry them until they are arrested in the fine capillaries of the lung. In this way it may be possible to treat cancers of the lung. Another possibility is to use the technique of cardiac catheterization, in which a fine tube is passed along the vein, through the heart and into an artery which feeds that part of the lung where a cancer has developed. Radioactive colloidal gold is thus located mainly in the region where the cancer is. If the particles are made small enough they will pass through all the lung capillaries and eventually be absorbed by the reticulo-endothelial cells, most of which are in the liver. This provides a method of irradiating the liver only, which may prove useful in treating certain types of leukæmia and cancer of the liver.

By making use of the chemical properties of the radioactive substances it is also possible to deposit the radioactive isotopes where required. The classic case is the treatment of toxic goitre merely by giving the patient a drink of water containing less than one ten-millionth of a gram of radioiodine. In some cases of cancer of the thyroid the secondary deposits can be induced to take up iodine in the same way as normal thyroid tissue. Hence, multiple deposits can be treated with radioactive iodine when they are too widespread for surgical removal.

Although the medical applications of radioactive isotopes are barely ten years old, they have already been developed for tests of the very highest value in research and of great convenience and some importance in routine clinical medicine. Their most important value lies in the clearer understanding that they are giving us of the body processes involved in health and disease, and in this type of investigation they are proving to have an increasing scope and power which is transforming many lines of medical investigation.

* Summary of a lecture by Dr. E. E. Pochin, being the fifth of the series of public lectures arranged by the Atomic Scientists' Association and the Department of Extra-Mural Studies of the University of London (see also *Nature* of February 27, p. 386; March 13, p. 477; March 27, p. 573; and April 3, p. 621).

THE PARLIAMENTARY AND SCIENTIFIC COMMITTEE

THE annual report for 1953 of the Parliamentary and Scientific Committee* records a Parliamentary membership of 166 in 1952, while some thirteen further scientific and technical organizations were elected to membership during the year. Meetings of the general committee were addressed during the year by Sir Frank Engledow, on primary factors in

* Parliamentary and Scientific Committee (an Unofficial Group of Members of both Houses of Parliament, and Representatives of certain Scientific and Technical Institutions). Annual Report, 1953. Pp. 28. (London: Parliamentary and Scientific Committee, 1954.)

African agriculture; by Mr. F. J. Curtis, on developing the managerial abilities of employees; by Mr. W. Allen, Mr. E. D. Hinchliffe and Mr. A. MacDonald, on economic benefits of a scientific factory design policy; by Sir Hubert Houldsworth and Dr. D. T. A. Townend, on coal production and utilization and the application of science thereto; by Sir John Hacking and Sir Harold Smith, on electricity and gas industries and the application of science thereto; and Dr. F. Roffey, Dr. R. F. Goldstein, Dr. R. Holroyd and Dr. M. A. Matthews introduced a discussion on the economic importance of the petrochemical industry. On June 16, 1953, it was agreed to set up a sub-committee to consider the whole question of higher technological education. The report includes the usual concise summary of representations made to the Lord President of the Council and of Parliamentary announcements relating to science and government during the year.

Addressing the Parliamentary and Scientific Committee at its annual luncheon on February 16, 1954, Dr. K. T. Compton, chairman of the Massachusetts Institute of Technology, said that technological education has been continually shaped to meet the needs of the country concerned. Civilian, as distinct from military, engineering schools were first developed in France and Germany about two centuries ago—in France, first as part of a national public-works programme under Louis XV, and then as part of an attempt to recover from the wreckage of the Revolution. In Germany, the impetus arose, first from the desire to recover from the economic destruction of the Napoleonic War, and secondly from her ambition to compete in industry and trade with Great Britain. The numerous polytechnic institutions and technical high schools thus established on the Continent of Europe were all State institutions, owing to university indifference or opposition. In the United States, the great impetus to engineering education came in the early 1860's; but in Great Britain the development of technical education was greatly influenced by the old guild traditions and laws governing apprenticeship, although Great Britain to-day has some of the world's best engineers.

Dr. Compton then directed attention to several trends which he thought were as significant in Great Britain as in the United States. First, the demand for engineers is increasing greatly and faster than the supply: the annual output of graduates from the United States engineering schools is less than half the forty thousand new engineers required. Secondly, the nature of the demands on engineers, and therefore the kind of education required to meet these demands, are changing: there is opportunity for at least some technological institutions to increase their emphasis on basic science and research, for a higher technological institution cannot just follow industrial trends but must anticipate and prepare for them. Moreover, to an increasing extent the most progressive technological institutions are providing education for many who are not planning to be professional scientific workers or engineers, but who see in these fields a good introduction to the cultural environment of to-day and a good medium for intellectual discipline. In this way higher technological education is helping to develop the industrial and social climate in which technological progress and productivity can thrive.

Stressing the importance of the factor of 'climate' and prestige within which the technologist works, as well as the more obvious factor of his specialized competence, Dr. Compton expressed the opinion that the Government of Great Britain has been wise to support both the technological departments of the universities, through the University Grants Committee, and also the expansion of the Imperial College of Science and Technology, London. He thought that the diverse approach, through the universities and through higher technological institutions, has virtues in healthy competition, greater coverage, mutually supplementing programmes, and the general advantage of wider education, experiment and spreading of investment risks.

QUARTERLY JOURNAL OF MICROSCOPICAL SCIENCE

PART 4 of vol. 94 of the *Quarterly Journal of Microscopical Science*, issued in December 1953, was chosen as the "Centenary Number", and indeed it is a centenary worthy of commemoration. Actually the first number was published in October 1852, so that it has been in publication for just over 101 years. The first editors were Dr. Edwin Lankester and Mr. George Busk, who were active members of the Microscopical Society of London, and it started as a joint publication, the first part of the volume being the *Journal of Microscopical Science* and the second part the *Transactions* of the Society. The editors were solely responsible for the *Journal*. Each volume contained not only original contributions but also translations of foreign papers, long reviews, notes, correspondence and extracts from the proceedings of various societies whenever they dealt with microscopy. It was issued by a well-known publisher, Samuel Highley, who retired in 1855, and then it was taken over by J. and A. Churchill. It catered for biology, geology, histology and pathology—indeed, any branch of science and medicine that was served by microscopy. From the commencement a strong point was made of the provision of plates by the well-known lithographer Tuffin West, and they became one of its outstanding features.

The volumes of the first series, which finished with Vol. 8 in 1860, give the impression of being the work of amateurs. The term is not used in any derogatory sense but to imply persons who either did not use the microscope as an essential tool of their calling or, if they did, were interested in its application to other fields. The contributions lack a common aim; the unifying factor is the instrument used, with its ancillary techniques. With the "new series" a gradual change set in, and the memoirs became more and more by and for professional biologists, to whom the microscope was essential in their work. Vol. 3 of the new series contained a review of the Gregarinidæ with descriptions of three new species. It showed a comprehensive grasp of the subject and familiarity with the relevant literature in French and German and appeared when its author, E. Ray Lankester, was sixteen years old. After Vol. 8 N.S., the *Transactions of the Royal Microscopical Society* (a Royal Charter had been granted in 1866) were published independently. The following year, 1869, it was only the quarterly journal; at the same time, Mr. Busk left it and the young Oxford B.A., E. Ray Lankester, joined it as co-editor with his father. Two years later Dr. Lankester, a man of unbounded energy and

most varied interests, retired, and Dr. J. F. Payne, of St. Thomas's Hospital, joined as co-editor, thus maintaining the link with medical microscopy. With Vol. 16, 1876, E. Ray Lankester became chief editor, but had a varying panel of collaborators chosen from the leading biologists of the country. There followed a period of remarkable growth, which reached a peak in 1885, during which year 912 pp. of text and 62 plates appeared, and a second peak in 1894, with 904 pp. and 84 plates. The former was towards the end of a period when the microscope had greatly facilitated the study of the invertebrates. By this time the *Journal* was without equal in Great Britain and had achieved a world-wide reputation. Behind much of this work was the background of the idea of evolution, and there grew up a sort of unity, lacking in the early years, in which each piece of morphology or embryology seemed to have a place.

The second peak was in part associated with the extended use of the microtome and the rise of vertebrate embryology, again with a distinctly evolutionary background, which occupied an increasing amount of space but not to the exclusion of the invertebrates, particularly Protozoa. During this expansion period the *Journal of Botany* and other specialist journals appeared, so that the "*Q.J.*" became more and more zoological. This tendency to restrict the scope of a publication seems to be inevitable; but it is to be hoped that it will not be carried to the extent that the *Quarterly Journal* becomes another of those journals not looked at save by workers in its own narrow field. E. Ray Lankester remained editor until Vol. 64, 1919, by which time he had contributed seventy-eight articles to it, a number of them becoming classics. He retired from active participation; but his name appeared as honorary editor until his death in 1929. Vol. 64 also marked fifty years of his editorship, and this was commemorated by Prof. G. C. Bourne in a long review of the outstanding memoirs that had appeared and the many distinguished names, both British and foreign, that had been associated with the *Journal*. He directed attention to one of the principal features of its outstanding success, the universality of its appeal, and that while it "had its specialities it has never been specialised". The new editor was Prof. E. S. Goodrich, a pupil of Lankester's at University College, London, whom he took with him when he went to the Linacre chair at Oxford. Goodrich's first contribution to the *Journal* was in 1893, and like his predecessor he was to prove a great editor and a great master of zoology. Three parts of Vol. 86, 1946, are taken up by a review of the work, largely by himself and his pupils, on the cœlom, genital ducts and nephridia that had appeared in the fifty years since his initial contribution to the problem. He died shortly after he had corrected the proofs of this, and before it had appeared in print, and so ended a connexion of fifty-two years with the *Journal*, for the last twenty-five of which he had been editor.

With the death of Prof. Goodrich the ownership of the *Journal* changed hands, its publication was taken over by the Clarendon Press, and Dr. C. F. A. Pantin, who had joined the panel of collaborators in 1939, and Dr. John Baker became joint editors. A comparison between the earliest and the latest volumes is interesting, and shows that a number of similar problems are investigated. The techniques, of course, differ, for the plain microscope is replaced by the electron and phase-contrast microscopes, etc., freeze drying and refined chemical (including staining) methods. It is essential to explore the possibilities and limitations of new techniques; but it seems to follow that the various contributions tend to lack the coherence so noticeable in the years before and after the turn of the century. It is interesting, too, in view of the present extensive use of photomicrographs, to find that this method of illustration was used for the first time, so far as has been traced, in one of the plates in the first volume of the *Quarterly Journal of Microscopical Science*.

The *Journal* is to be congratulated on its century and on the fact that it is "still going strong"; may it long continue to be the fertile source of inspiration that it has been in the past.

INORGANIC CHEMICAL KINETICS AND REACTIONS

A CHEMICAL SOCIETY symposium generally takes the form of a sort of scientific stock-taking at which progress and achievement in some chosen field are reported and the contemporary position impartially assessed. The symposium on "Inorganic Kinetics and Reactions", held at Burlington House, London, on February 4, was arranged by Dr. J. Chatt and Dr. L. E. Sutton rather to direct attention to a field of rapidly growing importance, and in his introductory remarks the president of the Society, Prof. C. K. Ingold, urged his many listeners to avail themselves of the opportunities open for British chemists to take their full share and—as he hoped—a leading part in its development.

The first paper, by Dr. H. M. N. H. Irving (Oxford), took the form of a general survey of problems and methods. After paying a tribute to Prof. Ingold for the great part he had played in raising our knowledge of the kinetics of organic reactions to such an advanced state, Dr. Irving suggested that the comparatively undeveloped state of inorganic kinetics is not due entirely to the general neglect—particularly in Britain—of inorganic chemistry as a whole, nor to the fact that inorganic reactions are often fast, for techniques for dealing with this problem are available. But while the organic chemist generally has a precise knowledge of the concentrations, compositions and detailed structures of the materials reacting in the systems he investigates, remarkably little is known in many cases concerning even the actual species which participate in an inorganic reaction such as that formally represented by the equation:

$$Sn^{2+} + 2Fe^{3+} \rightleftharpoons Sn^{4+} + 2Fe^{2+}.$$

The extent to which a cation is hydrated in solution, the firmness with which the primary solvation sheath is attached, the extent and rate of ionization of hydrogen ions from an aquo-cation to form water-soluble basic species or polynuclear complexes, and the effects of complex formation with all anions present—these factors are seldom known with any accuracy, though they may be of essential significance in elucidating reaction mechanisms and kinetics in inorganic chemistry.

Techniques for measuring the rates of inorganic reactions are already numerous, though dynamic flow methods and calorimetric methods have not

yet been extensively employed. Bjerrum's effective device of working at very low temperatures (− 75° to − 100° C.) has already provided interesting results. Great impetus has recently been given to the field by the general availability of radioactive and stable isotopes and ancillary counting equipment and mass-spectrographs.

A feature common throughout inorganic kinetics is the complexity of the processes taking place. For the exchange reaction of ferrous and ferric ions the rate equation may be written :

$$R = [Fe^{II}]\,[Fe^{III}]\,\{k_1 + k_2/[H^+] + k_X\,[X^-]\},$$

where the inverse rate-dependence on hydrogen-ion concentration shows that the (hydrated) species $FeOH^{++}$ is involved, while the term involving X^-(= Cl^-, NO_3^-, etc.) shows that ferric complexes of the type FeX^{++} are participating. But while the kinetics can be interpreted by postulating a transition state of the type $(III)Fe^{++}$—OH . . . $Fe(II)^{++}$, the effective exchange of charge which appears to take place may involve (i) actual transfer of an electron from right to left, (ii) transfer of a hydroxyl group, or (iii) transfer of a proton from a water molecule attached to the ferrous ion to the hydroxyl group.

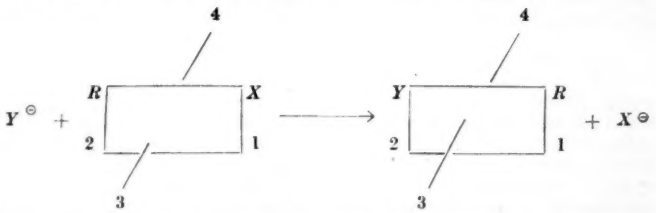
Exchange of a complex ML_n with a labelled ligand L^* may proceed either through dissociation (with or without an intermediate stage of aquation) or by an association process which involves an increase in the co-ordination number of the central atom. Examples of both types are known, and considerable progress has been made in correlating the ease of exchange with the type and strength of bonding in the complex. In organic chemistry, stereochemistry is dominated by the tetravalency of the carbon atom ; but in inorganic chemistry, planar, tetrahedral and octahedral dispositions provide a variety of new problems, some of which would be dealt with in the next paper. As an illustration of the unsolved problems of inorganic mechanism, Dr. Irving concluded by quoting the reaction of *D* — $[CoCO_3(l.pn)_2]^+$ with a 100 per cent excess of *d*-*l*-tartaric acid whereby the dextro-form displaces carbonate ion preferentially from the complex, thus effecting a partial resolution. Is this due to differing stabilities of the complexes containing *d*- or *l*-tartaric acid, or to different rates of reaction of the two enantiomorphs with the carbonatocobaltic ion ?

Prof. C. K. Ingold (London) then spoke on the "Mechanism and Stereochemistry of Octahedral Substitution", dealing first with the kinetics of chlorine displacement from *l*-*cis*-dichloro*bis*ethylenediaminecobalt-III by a graded series of nucleophilic reagents (X^-) such as MeO^-, N_3^-, NO_2^-, SCN^-, Br^-, Cl^- and NO_3^-. Kinetics were followed by a variety of techniques such as polarimetry, spectrophotometry, titrimetry, and the use of radioactive chlorine-36. While bimolecular reactions occur with the first three reagents named, nucleophilic substitution proceeds by S_N1 mechanism with the last four. Since optical activity is completely lost, and at the same rate, in these last four cases, the following mechanism was proposed by Prof. Ingold :

$$[CoEn_2Cl_2]^+ \xrightarrow[\text{Slow, rate controlling}]{-Cl^-} [CoEn_2Cl]^{++} \xrightarrow[\text{rapid}]{X^-} [CoEn_2ClX]^+$$

The short-lived, optically inactive intermediate contains 5-covalent cobalt-III and may be formulated as a triangular bipyramid or as a square pyramid. It can take up the substituting agent at comparably rapid rates in all the distinguishable five positions in proportions which depend in detail on the groups already present, and on the nature of that entering.

Prof. Ingold pointed out that a most confusing variety of stereochemical changes among co-ordination compounds of the type CoR_4AX has been reported on replacing *X* by *Y*. If these are bimolecular and proceed by edge-displacement, the type of configurational change observed depends essentially upon the atom chosen as the reference point. If this were atom 1, the edge-displacement could be described as a *cis* → *trans* change ; if at 2, as *trans* → *cis* ; if at 3 or 4, as either



d → *l*, or *l* → *d*. Indeed, if certain geometrical conditions are satisfied, edge-displacement can proceed without apparent geometrical isomerization or change of optical configuration. In two cases the steric course of an S_N2 change has been studied in detail, with the following results :

		per cent *cis*	per cent *trans*
trans-$[CoEn_2(SCN)Cl]^+ \xrightarrow{OH^-}$	$[CoEn_2(SCN)(OH)]^+$	72	28
trans-$[CoEn_2(SCN)Br]^+ \xrightarrow{OH^-}$	$[CoEn_2(SCN)(OH)]^+$	75	25

showing that substitution in octahedral complexes proceeds predominantly, but not exclusively, by 'edge-displacement'. This result should be contrasted with S_N2 substitution among tetrahedral carbon compounds, which leads practically exclusively to optical inversion.

The next speaker, Prof. F. S. Dainton (Leeds), prefaced his paper entitled "Physico-chemical Mechanisms involved in Electron Transfer" by saying that he proposed to underline some of the general remarks made by Dr. Irving. Atom transfers are certainly known, such as

$$(S\,{}^{16}O_3)'' + (Cl\,{}^{18}O_3)' \rightarrow (S\,{}^{16}O_2{}^{18}O)'' + (Cl\,{}^{18}O_2{}^{16}O)' ;$$

and electron transfers between, for example, argon and sodium vapour are well established. But while Tl^+ and Tl^{3+}, and Fe^{2+} and Fe^{3+} give couples individually reversible at a platinum electrode so that the position of ultimate equilibrium in a mixture can be calculated from the redox potentials, these give no clue to the rate of reaction.

The fundamental principles of electron transfer reactions were then discussed by Prof. Dainton along the lines suggested by Mulliken, and by Evans and his co-workers. Vinyl compounds which are polymerized by hydrogen atoms serve as detectors for hydrogen atoms produced, for example, by photochemical electron-transfer from reducing ions, though it is always necessary to take into account possible complex formation between cations present and the

vinyl compound used; acrylonitrile displaces the potential of the V^{2+}/V^{3+} couple by as much as 0·78 V. due to preferential complexing with the vanadous form. Prof. Dainton reviewed the relationship between ionization potential and electron transfer spectra in considerable detail and discussed the effects of complexing the reducing ion. He concluded with an exposition of contemporary theoretical views on the process of electron transfer in systems of the type $A^{zA} \ldots X \ldots B^{zB}$ in which X forms a conducting path, and paid particular attention to the possibilities of tunnelling effects and to changes in the entropy of hydration caused by valency changes in the cations A and B.

Dr. J. H. Baxendale described current work at the University of Manchester in his paper on "Some Aqueous Oxidation-Reduction Reactions". The low probability of termolecular reactions suggests that a non-symmetrical redox reaction, such as

$$Tl^{+} + 2Fe^{3+} \rightleftharpoons Tl^{3+} + 2Fe^{2+},$$

which formally involves a two-electron transfer, might proceed through intermediates having abnormal valency, for example, Tl^{2+}. Higginson *et al.* have shown that the oxidation of hydrazine takes different courses, depending on the oxidant employed. Using nitrogen-15, it has been confirmed that there are two alternative reaction paths:

$$\begin{array}{ccccc} & & N_2H_3 & \rightarrow & \tfrac{1}{2}N_4H_6 \rightarrow \tfrac{1}{2}N_2 + NH_3 \\ & +e \nearrow & & & \\ N_2H_4 & & \Big\downarrow +e & & \\ & +2e \searrow & & 2e & \\ & & N_2H_2 & \rightarrow & N_2 \end{array}$$

which may be taken, depending upon whether the oxidant used reacts in the first step by accepting a single electron, or two electrons simultaneously.

With hydrogen peroxide there is again a possibility of two reaction paths, depending upon conditions; for this substance may either be oxidized quantitatively to water and oxygen, or it may be induced to undergo catalytic decomposition by way of self oxidation-reduction. Using reagents of high redox potential, a detailed study has been made of rates and mechanisms. In almost all cases the rate equation contains two terms, one of which involves the reciprocal of the hydrogen-ion concentration. The kinetic dependence on pH in the case of oxidation by cobaltic ions is consistent with any one of the following mechanisms:

$$Co^{3+} + HO_2^{-} \rightarrow Co^{2+} + HO_2 \text{ (electron transfer)}$$
$$CoOH^{2+} + H_2O_2 \rightarrow Co(H_2O)^{2+} + HO_2 \text{ (atom transfer)}$$
$$CoO_2H^{2+} \rightarrow Co^{2+} + HO_2 \text{ (dissociation)},$$

illustrating the great difficulties which attend the interpretation of kinetic data and the need for more detailed information concerning the stability and probable behaviour of metal complexes in solution.

The last part of Dr. Baxendale's paper dealt with the mechanism and kinetics of reactions of ferrous–ferric and thallous–thallic couples with some quinone–hydroquinone systems. While the kinetics are consistent with reactions proceeding through a reversible one-electron step involving an ion of abnormal valency (for example, Tl^{2+}), followed by a second one-electron step, there is once again the common ambiguity as to whether electron transfer, or atom transfer, or the transfer of a group is involved.

After a break, the symposium was resumed under the chairmanship of Dr. J. Chatt. The first paper, on the "Disproportionation Reactions of the Heavy Elements in Aqueous Solution", was given by Dr. R. Hurst (Harwell), who discussed the oxidation-reduction potentials of couples formed by different valency states of uranium, neptunium, plutonium and americium. In every case the formal redox potentials are greatly influenced by the nature and concentration of acids present, pointing to extensive complex formation, while the closeness of values for different oxidation states points to their possible co-existence in solution. Thus plutonium exists in 0·05 M perchloric acid to the extent of 10, 3, 24 and 63 per cent in the tri-, tetra-, penta- and hexa-valent states respectively, and disproportionation reactions, such as

$$PuO_2^{+} + Pu^{4+} \rightleftharpoons PuO_2^{++} + Pu^{3+}$$
$$4H^{+} + PuO_2^{+} + PuO_2^{+} \rightleftharpoons Pu^{4+} + PuO_2^{++} + 2H_2O$$
$$4H^{+} + PuO_2^{+} + Pu^{3+} \rightleftharpoons 2Pu^{4+} + 2H_2O,$$

proceeding at different speeds, further complicate the picture. The interacting species are less simple even than already suggested, for from the effect of changing hydrogen-ion concentration on the rate of the back-reaction in the third equation, it would appear that the two tetravalent plutonium ions ought rather to be differentiated as $Pu(OH)^{3+}$ and $Pu(OH)_2^{2+}$, respectively. When studying the solution chemistry of the heavier radioactive elements, still other complications arise from side-reactions induced by the effects of intense radiation on the solvents and reactants.

Dr. K. W. Sykes (Swansea), who followed, further emphasized the importance of an exact knowledge of the concentration and nature of the species present before embarking on attempts to elucidate reaction kinetics. Although perchlorates have almost universally been used as standards of non-association, he questioned the validity of assuming that complex-formation between cations and perchlorate ions is always negligible. Using spectrophotometric methods, he investigated the interaction of ferric ions with perchlorate, sulphate, bisulphate and hydroxyl ions, taking into account the possible formation of an equilibrium mixture of all the possible binary complexes, as well as mixed complexes such as $Fe(OH)_k(ClO_4)_{k}^{2-k}$. The value found for the stability constant $(FeClO_4^{2+})/(Fe^{3+})(ClO_4^{-}) = 19$ ($\mu = 0$) indicates considerable association, a result consistent with most other spectrophotometric studies and with the effect of perchlorate ion on the kinetics of the ferric iodide reaction.

The last paper in the symposium, dealing with "Hydrolysis and Exchange Studies of some Chromic and Cobaltic Complexes", was presented by Dr. R. G. Wilkinson (Sheffield) and described work carried out in collaboration with Dr. A. W. Adamson (University of Southern California). For the aquation reaction

$$[Cr(NH_3)_5(SCN)]^{++} + H_2O \rightleftharpoons [Cr(NH_3)_5(H_2O)]^{+++} + SCN^{-},$$

the first-order rate constant was found to be $k = 1{\cdot}17 \times 10^{13} \exp(-24{,}900/RT)$; but the rate of bimolecular exchange of thiocyanate ion with the thiocyanatopentammine containing the labelled group $S^{14}CN$ was found to be not more than a few per cent of the aquation-rate and undetectable against the

aquation background. For the first-order aquation of the corresponding cobaltammine, however,

$$[Co(NH_3)_5(SCN)]^{++} + H_2O \rightleftharpoons [Co(NH_3)_5(H_2O)]^{+++} + SCN^-$$

the rate was given by $k = 0{\cdot}85 \times 10^{13} \exp(-26{,}800/RT)$. While in this case aquation and the rate of release of thiocyanate ions was found to be catalysed by thiocyanate ions, no similar rate-enhancement was observed with the chromammine. These differences could be explained by postulating the operation of an association (S_N2) mechanism for the chromium complexes, but a dissociation (S_N1) mechanism for those of cobalt. But it should not be overlooked that the rate of exchange of water is known to be increased in many cases by increase in ionic strength, so that the catalytic effect of the thiocyanate ions might well be due to their causing an increase in ionic strength rather than to the progress of a bimolecular substitution.

The lively and prolonged discussions which followed each group of papers brought valuable contributions from a very considerable number among the audience and added greatly to the success of what was obviously an exceptionally well-appreciated, stimulating, and well-timed symposium. Since the whole of these discussions is to be reported in full by the Chemical Society in a special publication of all the papers contributed to the symposium, no attempt will be made here to indicate even their scope or quality; but they certainly suggested that the hopes expressed by the president in his opening remarks would not long await realization.

H. IRVING

UGANDA PROTECTORATE FOREST DEPARTMENT

ANNUAL REPORT FOR 1952

THE annual report of the Uganda Forest Department for the year ending December 1952* makes an outstanding departure from the forestry reports of most of the British Colonies—and, it might be added, other parts of the Commonwealth—by virtue of the noteworthy position it gives to a consideration of working plans. This important branch of forestry work is dealt with under the heading of "Enumerations and Working Plans" in Chapter 3, and follows remarks on policy and legislation in Chapter 1, the form of which remains unchanged and on the lines of the official statement made by the Governor in 1948, and data on the forest estate for the year, which are contained in Chapter 2.

A working plan for a forest is not necessarily made only when an annual financial income is assured. A chancellor of the exchequer or financial minister to a Colonial Government has to provide money in his budget for non-productive objects of indirect benefit to the community. In a similar fashion, forests may have to be managed, especially protection forests or those which secure amenities for the public but do not make a direct financial profit. As regards financially productive forests, a working plan is necessary even though the area may be run on a short rotation for the public, often to provide the agricultural villager with fuel. Once under a working plan sanctioned by the highest Civil authority in the country, a forest is safe in perpetuity so long as the prescriptions laid down for a short period of years are strictly carried out. A perusal of the chapter in this report devoted to this branch of forestry work shows that these premises are well understood by the Government and the Chief Conservator of Forests in Uganda. Equally interesting are the remarks on the methods upon which the enumerations of the growing stock of the forests are being undertaken; for a plan cannot be drawn up until as detailed a knowledge of the contents of the forest as possible is obtained.

Five new working plans were approved during the year, and progress was made in the compilation of a number of other plans and revisions, some being in first draft during the year. One of the sanctioned plans, the Mbale Plantations for 1953–60, is for pole and fuel plantations covering a coppice rotation; another prescribes the management of six protection central forest reserves in the northern Acholi hills; a third, the West Nile Southern Escarpment hill-tracts working plan for 1952–61, prescribes the protection and maintenance of nine local forest reserves in the West Nile. The mere names and the reasons for these working plans indicate the sound lines of work which the Chief Conservator is engaged upon.

It is all the more satisfactory and of promise for the future that working plans are in force or in preparation for local forests under African management. The area of pole or fuel plantations, twelve in number, managed by African local governments amount to 7,691 acres, of which several are already under working plans. This type of work in tropical forests involves a considerable amount of research, and the staff of the Department are to be congratulated on the amount of work which has been carried out on this account.

E. P. STEBBING

* Uganda. Annual Report of the Forest Department for the Year ended 31st December, 1952. Pp. ii+38. (Entebbe: Government Printer, 1953.) 1.75s.

CARNEGIE INSTITUTION OF WASHINGTON

ANNUAL REPORT

DR. VANNEVAR BUSH'S annual report* as president of the Carnegie Institution of Washington mentions as the most interesting of the Institution's research activities in the year ending June 30, 1953, an entirely new approach at the Mount Wilson and Palomar Observatories to the problem of the general magnetic field of the sun. Observations made possible by the greatly increased power of the new Mount Wilson gratings, and new photoelectric techniques have confirmed the existence of a general magnetic field much weaker than earlier measurements suggested and limited to the neighbourhood of the poles. Preliminary values obtained with the new Hale telescope and more advanced techniques now available indicate that a drastic revision of the distance of the Andromeda nebula and other distances dependent on it will be required: the earlier values of the distances and linear dimensions of all nebulæ must be approximately doubled

* California Institute of Technology. Annual Report 1952–1953. Comprising the Reports of the President, the Secretary, the Comptroller, and other Administrative Officers. Pp. v+142. (Pasadena, Calif.: California Institute of Technology 1953.)

and their luminosities quadrupled. During the year a new and extremely sensitive light-measuring device in the form of a photon-counter has been developed for the Hale telescope, by which light received from an object can be measured at the extreme limit that can be photographed with the 200-in. telescope.

Improved techniques have now surmounted experimental difficulties which hampered work at the Geophysical Laboratory on rock-forming minerals mixed with volatile components, and a better understanding is being obtained of the process of formation of granite, as well as new insight into the chemistry of the micas. Apparatus is now in use which can give pressures up to 200,000 lb./sq. in. at temperatures of 1,000° C. or higher, and studies with this apparatus indicate that the solubility of solid inorganic substances in compressed gases can reach unexpected magnitudes.

In the Department of Terrestrial Magnetism, by measuring the incorporation of isotopically labelled compounds in bacterial cells, flow patterns have been obtained which account for more than 80 per cent of the carbon incorporated: this is converted from glucose to the amino-acids, purines and pyrimidines eventually used in the synthesis of protein and nucleic acid molecules. Studies of the Krebs cycle show that in *Escherichia coli* growing with glucose as the sole source of carbon, the Krebs cycle acts chiefly by synthesizing aspartic and glutamic acids, and contributes little to oxidation, although in certain circumstances the flow alters to emphasize oxidation rather than synthesis.

Studies of winds in the upper atmosphere and a revised understanding of the electrical conductivity of the ionosphere now suggest that the electrical currents which produce magnetic storm effects are primarily in the atmosphere, and the wind motions causing them are initiated by radiations and possibly by particles from the sun. In the Department of Plant Biology, the biochemical group has shown that the reversible changes in the absorption spectrum of chlorophyll in certain photosynthetic bacteria are increased when oxidizing substances are added to the bacteria and decreased in the presence of substances, such as peptone, that enter into the normal metabolism of the cells. The change, by absorption of light, of protochlorophyll to the photosynthetic pigment, chlorophyll, occurs in leaves even at − 77° C., although the rate of change and its extent diminish below 0° C. Studies in the Department of Genetics of reproduction in bacteriophages have partly confirmed the view that infection of the bacterium *Escherichia coli* by bacteriophage T_2 begins with the injection of pure phage nucleic acid into the cell. The findings are consistent with an intracellular population of multiplying non-infective phage and with the idea that non-infective phage particles consist of or contain nucleic acid. Presence of a mutation-inducing factor at a particular locus in a maize chromosome results in the production of a large number of mutations affecting the action of genes on either side of it.

In the Department of Embryology, a noteworthy advance has been made in a study of the action of the blood circulation, especially of the lungs of the new-born animal just before and just after the time of its birth. Further work on the physiology of uterine muscle has shown that progesterone produces its effects on muscle tissue by altering the rate of access of potassium ions to the contractile tissue.

VARIATION WITHIN INBRED STRAINS OF MICE

By Dr. H. GRÜNEBERG

University College, London

THE use of inbred strains of mice and other rodents has been widely recommended for experimental purposes. The advantage of highly inbred over ordinary mice is held to be that the members of an inbred strain are genetically very similar and hence presumably more uniform both anatomically and physiologically. As a consequence, an experiment carried out with a given number of inbred animals is expected to give a result of greater precision than if the same number of ordinary mice had been used. Moreover, an experiment carried out by *A* would be more accurately repeatable by *B* if both use the same standard inbred strain of animals than if they use batches of ordinary mice.

The confidence with which inbred strains have been recommended for general experimental use rests largely on the prestige of the mathematical theory of the results of inbreeding; or, more properly, of an early phase of that theory. For example, it can be calculated what progress towards homozygosity will be made by ten or twenty generations of brother–sister mating in the absence of selection. In practice it is, however, difficult to avoid selection in favour of the more fertile heterozygotes, and it has recently been shown[1] that a comparatively moderate advantage of the heterozygotes over the homozygotes can greatly retard and indeed completely arrest the progress towards the fixation of genes by inbreeding. Recent work in *Drosophila*[2] has shown that the selective advantage enjoyed by many genes and gene complexes in the heterozygous, as compared with the homozygous, state is surprisingly great; no comparable data are yet available for the mouse or other mammals. Heterozygosis in an inbred strain is also replenished by mutation and hence depends on the total spontaneous mutation-rate, for which no estimates are as yet available in the case of mammals; it may be high as compared with *Drosophila*, as was found to be the case for the induced mutation-rate in a number of selected loci in the mouse[3]. Taken together, residual heterozygosis and heterozygosis due to mutation constitute the irreducible heterozygosis in a pure line. Its level will be reflected in the extent to which the pure line is split up into genetically different sub-lines in the course of continued inbreeding. It is the level of this irreducible heterozygosis (rather than its source) which is of primary interest for all practical purposes.

That pure lines of mice do, in fact, split up into genetically distinguishable sub-lines in the course of continued inbreeding has become obvious in recent years through the appearance of coat colour mutations, of histo-compatibility genes and, more recently, of structural differences such as the number of pre-sacral vertebræ[4,5]. In all these cases, changes in a single feature only have been studied, and while such facts have given qualitative evidence for sub-line development, they have not been suitable for quantitative studies of that process.

Material highly suitable for the quantitative study of variation within pure lines has become available

in recent years. It has been discovered that there exists a multitude of well-defined variations in the skeleton of the mouse[6–12], most of which had previously escaped detection. More than a score of these variants have so far been studied to a greater or lesser extent, and others remain to be sorted out. These include various features of the skull and teeth, of the vertebræ (particularly in the cervical and upper thoracic region) and of the pelvis. Few, if any, of these variants are pathological. Some are confined to a single pure line; others are found in several inbred stocks though usually in different percentages; these differences between pure lines are evidence that these entities are, to some extent, under genetic control. In most cases, normals can be distinguished from abnormals without ambiguity though the degree of abnormality is often variable. While most of these variants can thus be treated as all-or-none characters, none of those so far studied is due to the segregation of a single gene; there is evidence that many of these entities have a multifactorial background[6,8,10]; it seems that most of these characters are examples of 'quasi-continuous' variation[8] in the sense that they are satellite characters of continuous (metrical) variations which tend to appear whenever part of the continuous distribution crosses a particular threshold; for one case (absence of third molars), this has been directly demonstrated[7], the continuous variable being the size of these teeth when present. As there are thus numerous characters (few of which seem to be closely correlated with each other[8,11]) which are each under the control of many genes, the simultaneous study of all these entities within a pure line is a very sensitive tool for the discovery of genetic differentiation between sub-lines.

In Table 1 is given the percentage incidence of eleven such variants in the three pure lines *C57BL/Gr*, *CBA/Gr* and *A/Gr*. All three lines were well-established inbred strains when first imported from the United States in 1932, and brother–sister mating has continued ever since. The *C57BL* stock consists of four sub-lines which fall sharply into two groups (1 + 2 and 3 + 4, respectively); all these trace back to a pair born in 1941; from the common ancestor of all four sub-lines to the common ancestor of 1 and 2 there are about nineteen generations, and about fifteen generations to the common ancestor of 3 and 4; the main bulk of mice in 1 and 2 are four generations from their common ancestor and those in 3 and 4 are six generations. Four out of eight variants in Table 1 which occur in the *C57BL* strain show highly significant differences between groups of sub-strains (1 + 2 as compared with 3 + 4). In another two instances, one of the two groups is split up further (1 *vs.* 2, and 3 *vs.* 4), and in one instance (not given in Table 1) there is clear evidence[11] for a further splitting up of families within a single subline. Similar evidence comes from other mouse pure lines (ref. 11 and unpublished). While much more work is needed to fill in the details, it is obvious that mouse pure lines are far less homogeneous genetically than has been commonly assumed. Nor can this situation be improved by cutting down the stock periodically to the offspring of a single pair as is customary in some laboratories; while this reduces the co-existence of genetic differences in space, it increases genetic fluctuations in time.

Apart from the genetical variation due to sub-strain formation and due to sex, the skeletal variation within a pure line of mice is mainly due to intangible factors which affect individuals within a litter (or even sides of an individual) as units and which are commonly described as accidents of development; these accounted for more than 80 per cent of the total variance in three-quarters of the characters studied[11]. The remainder of the variance is due to environmental factors which tend to affect litters as a whole, such as litter size, parity, maternal age, gestation length and, in one instance at least (size of third molars[13]), lactation. The overall picture is thus similar to that found in previous analyses of the sources of variation in the guinea pig and in the mouse.

Table 1. Percentage Incidence of Eleven Skeletal Variants in Three Inbred Strains of Mice; for one of them (*C57BL*), Data for Two Groups of Sub-lines are given separately (Significant Differences in Italics).

The percentages refer to animals except in the variants marked with asterisks, which refer to sides of animals

Variant	Ref.	*C57BL/Gr* 1 + 2	*C57BL/Gr* 3 + 4	*CBA/Gr*	*A/Gr*
Interfrontal	9, 10	***54·7***	***72·3***	86·2	11·7
Parted frontals	9, 10	1	2	83	29
Pre-sphenoid preoptic sutures*	10	***25·5***	***48***	**94·5**	**99·5**
reduced metoptic roots*	10	1·5	0·5	72·5	22·5
Absence of 3rd molars	6, 11	0·2	0	17·9	3·5
Dyssymphysis of C1 and C2	6, 11	***43·5***	***51·5***	0	0
Cervical fusions	6, 11	3·7	***11·6*** 3·7	0	0
Dystopia tuberc. ant. of C6	6, 8	0	0	6·4	0
Lumbo-sacral variation, ♂♂	11	***21·2***	***5·3***	?	17·3
For. acetabuli perforans*	8	0	0	64·8	0
Dyssymph. ischio-pubica, ♀♀	8, 11	***95·6*** ***35·6***	85·1	0	0

As mentioned above, the genetic background of most of, or all, these skeletal variants is multifactorial. As such, one might expect them to be easily influenced by changes of the (pre-natal) environment. Indeed, quite a small change in the diet of the parents (from diet 86 to diet 1 of the Rowett Research Institute) had a clearly detectable influence on a metrical character in the *A/Gr* pure line, the size of the third molars[13]. A drastic change of diet (from the near-optimal diet 86 to a very unbalanced regimen of oats and a little hay) massively changed the incidence of nine out of twelve variants studied in the *C57BL/Gr* pure line (Table 2[13]). The changes were by no means all in the same direction; the incidence of some variants went up, that of others went down, while a few characters did not seem to be influenced at all. A particularly interesting case is that of dyssymphysis of the second thoracic vertebra in which the spinous process is split longitudinally. This variant did not occur in the controls, but was common on the oats diet; it is found rarely (about 1 per cent) in a distant branch of the same *C57BL/Gr* sub-strain and is very common, on a normal diet, in the *C57BL-b* sub-strain maintained at the Jackson Memorial Laboratory, Bar Harbor, Maine, U.S.A. Evidently, all these branches of the *C57/BL* 'family' are capable of producing this variant; in some sub-strains the feature is largely above the threshold, while in others it crosses it but rarely. But even in a sub-strain in which the variant is normally completely submerged, it can be raised above the threshold by a suitable change of diet.

Table 2. Percentage Incidence of *C57BL/Gr* Variants on Two Different Diets[13]

Variant	Diet 86	Oats	χ^2_1	*P*
Interfrontal	36·5	57·1	8·27	0·004
Parted frontals	3·6	20·0	6·17	0·015
Squamosal-parietal fusion	15·8	1·4	8·56	0·004
Occipital-periotic fusion	7·9	4·3	0·51	0·50
Dyssymphysis of C1 and C2	51·5	51·4	0·00	0·99
Dyssymphysis of Th 2	0	16·4	—	0·000

Features of the skeleton are the material of the vertebrate palæontologist and, to a large extent, of the physical anthropologist. There has been some bias in ascribing skeletal differences, particularly between human groups, to heredity rather than to factors of the environment. The facts just related are a salutary reminder that even the skeleton is far from immune from environmental influences, and a skeletal difference between two populations (whether in space or in time) may well have a purely nutritional basis. Of course, it would be absurd to suggest that long-continued trends in skeletal change can be accounted for on this basis.

The total variability of a population is commonly regarded as the sum of its genetic and environmental components. On the basis of this reasoning, it has sometimes been taken for granted that the reduction of the genetic variance by inbreeding will automatically be accompanied by a corresponding reduction of the total variance. An inbred strain (apart from sub-line formation) should thus be less variable than a genetically mixed population. This expectation based on general grounds clearly requires to be confronted with reality. This may be done by comparing the variability within pure lines with that of crosses between pure lines[7,8]. From the data so far available, it is certain that inbred mouse strains are by no means always less variable than genetically mixed populations. On the contrary, in several cases, the pure lines are far more variable than the F_1 and even the F_2 generations derived from crosses between them. This is in agreement with recent work on *Drosophila*[14,15], *Primula*[16], *Lycopersicon*[17] and other organisms, and evidently means that, at least for some of the multifactorial characters here considered, the homozygous state tends to be less stable developmentally than the heterozygous condition. (This incidentally means that, in biometrical genetics, it is no longer admissible to treat the total variance as if it were the sum of the environmental and the genetic variance. That treatment implies that the two components are independent of each other, whereas it now appears that the environmental may be a function of the genetic variance.) While, in some of the cases just considered, pure line animals are more variable than heterozygotes, the situation is clearly quite different, for example, in the case of antigenic characters (histo-compatibility genes, etc.) where, in tissue transplantation experiments, the reaction of pure-line animals is vastly more uniform than that of a genetically mixed batch of mice. Similarly, in cancer research, the superiority of pure-line mice has been established beyond doubt. [See also p. 686 of this issue of *Nature*.]

Summary. There is evidence that pure lines of mice are much less homogeneous genetically than is widely believed. It also appears that, in the case of some multifactorial characters at least, the homozygous state tends to be less stable developmentally than the heterozygous one. It follows that, while pure-line mice are superior material for certain types of experimentation, they may be inferior to genetically mixed animals for other purposes. [Jan. 1.

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RADIOCARBON AND SOME APPLICATIONS IN BIOCHEMISTRY

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FOR the biochemical investigations to be undertaken with radiocarbon in these laboratories, measuring methods of special sensitivity had to be developed. In particular, the Geiger counting of carbon dioxide gas is now carried out here as a routine method. At first, carbon dioxide at a pressure of up to 5 cm. mercury was added to the usual argon-alcohol mixture[1]. Later it was found, contrary to the experience of previous authors, that Geiger counters can be operated with fillings of pure carbon dioxide[2]. A Neher–Pickering quenching circuit is used; resolving power is small, but this does not matter as the gas-counting method is in any event used for weak samples only. The counters have a volume of about 25 c.c., and are filled to a pressure of 40 cm. mercury. The plateau is excellent (Fig. 1), and is not critically affected by water or mercury vapour. The measured activity is, of course, strictly

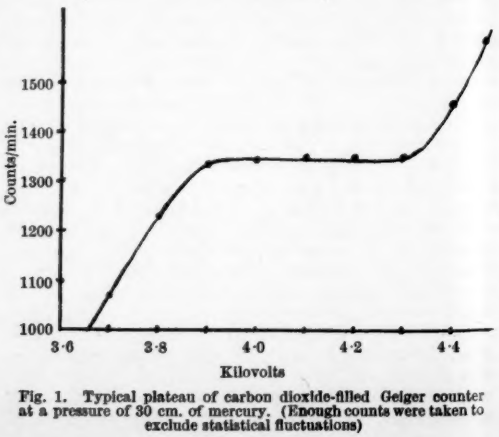

Fig. 1. Typical plateau of carbon dioxide-filled Geiger counter at a pressure of 30 cm. of mercury. (Enough counts were taken to exclude statistical fluctuations)

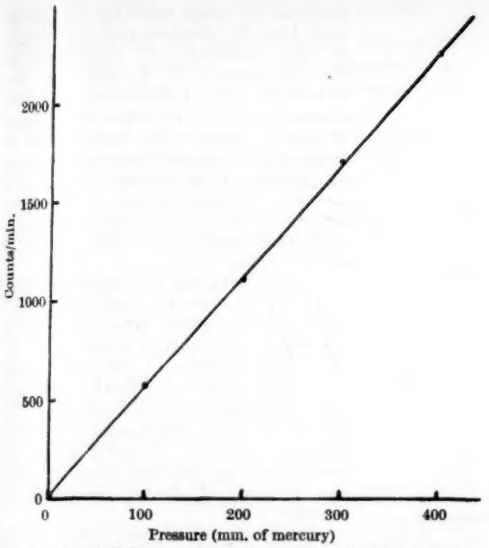

Fig. 2. Activity as a function of carbon dioxide pressure

proportional to pressure (Fig. 2). No prolonged pumping is required between the fillings, so that twenty or more samples can be measured per day. No 'memory effect' was ever observed. Numerical comparison shows that for weakly active samples of a mass of the order of a millimole, this method of measurement is probably the best[3]. In particular, it exceeds in sensitivity the determination of radiocarbon with the window counter by two orders of magnitude.

More recently, Dr. M. Reinharz, of these laboratories, has tested in Brussels, in collaboration with Dr. G. Vanderhaeghe, a photographic method for the assay of radiocarbon[4]. A solution of the active material is introduced into a glass capillary, which is embedded in an electron-sensitive nuclear emulsion by pouring the liquid emulsion over it. After a few days, the plate is developed and the beta-ray tracks are counted under the microscope. The background in this method is very low ($\sim 10^{-15}$ curie/cm. tube-length). Thus, activities can be measured smaller than those measurable with any other method by a factor of at least 10^3. The volume of the capillary being minute ($\sim 3 \times 10^{-4}$ c.c./cm.), the method is useful mainly for very small samples. Such samples occur in the analysis of chemical fractions from small organs of animal or plant origin. The method will be suitable for measuring the activities of individual cells.

The gas Geiger counter has been used to redetermine the capture cross-section of the carbon-13 isotope for thermal neutrons[5]. It has been found that this cross-section is at least ten times smaller than was believed previously, and cannot much exceed that of carbon-12. It follows, then, that the major part of neutron capture in natural carbon is due to carbon-12, which is eighty-nine times more abundant than carbon-13.

One of our main problems in biochemistry is that of the metabolism of individual tissue cultures of animal origin. Owing to the smallness of the masses of these cultures (dry weight of the order of 0·01 mgm.), very little is known about this metabolism. In collaboration with Dr. L. Stockinger and his group, of the Histological Institute of the University of Vienna, we have fed these minute tissue cultures radio-glucose and -fructose of exceedingly high specific activity. After the usual incubation period of two days, weighable quantities of suitable carriers, for example, fats or amino-acids, are mixed with the cultures, chemical separations are performed, the individual fractions obtained are subjected to combustion, and their activities measured. These activities indicate how much sugar the tissue had converted into the fractions. Very careful tests were carried out to exclude spurious activity due to adsorption[6].

It has been found that individual cultures of connective tissue take up in two days around 2×10^{-6} gm. of sugar each, corresponding to about 0·2 per cent of their own weights. About one-half of the activity recovered in metabolites appears as that of the end-product of respiration, namely, carbon dioxide. The activities of the following fractions have also been measured: free amino-acids + bases, proteins (after hydrolysis), lipoids, carbonic acids[7]. These fractions are being sub-divided.

It is intended to compare by this method the metabolisms of normal and cancerous cultures of similar origin. Using for such studies tissue cultures, the metabolism of uniform ('pure') tissue and not that of an ill-defined complex mixture of different tissues (as in the case of experiments with whole animals, or even tissue slices) is observed.

The very active sugars supplied to the cultures have been prepared by photosynthesis[8,9]. Radioactive carbon dioxide is assimilated by green leaves, and the sugars are extracted. To gain specific activity, a leaf of small mass (dry weight *c.* 6 mgm.) is induced to take up as much radioactive carbon dioxide as possible. No carrier is used in the extrac-

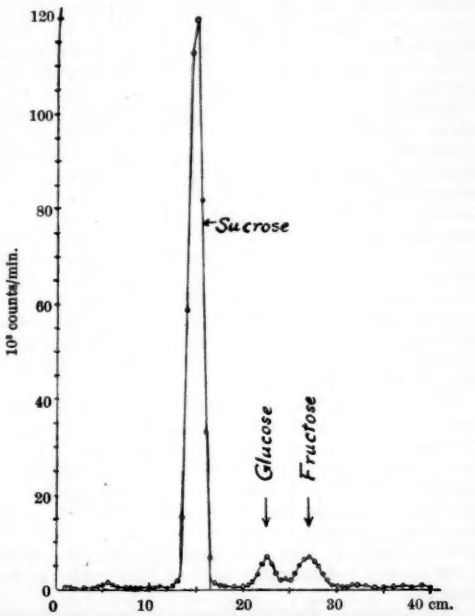

Fig. 3. Typical radiochromatogram on paper after passage of the solution through the ion exchanger (butyl alcohol – acetic acid – water)

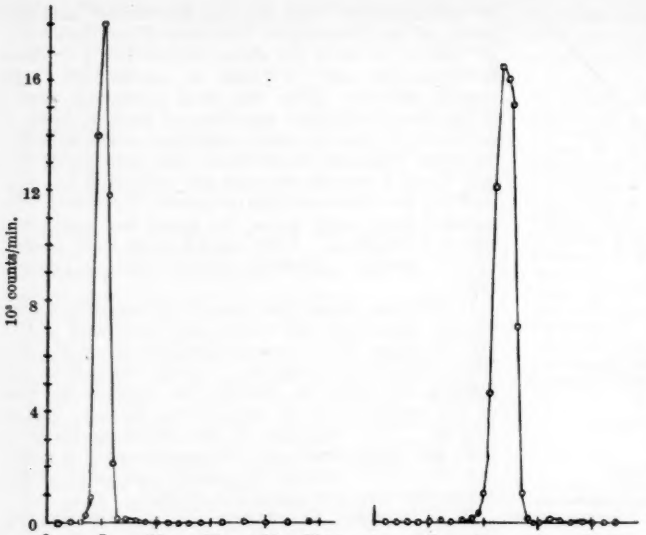

Fig. 4. Paper radiochromatogram of the sucrose eluted from the chromatogram shown in Fig. 3

tion. Naturally, precipitation reactions are excluded, as the total yield of sugar is less than 1 mgm. The sugars remain in the liquid phase, and are separated and purified by ion exchange and paper chromatography. The purity of the sugars (Figs. 3 and 4) is very satisfactory. Specific activity, starting from carbon dioxide containing 12 per cent carbon-14 dioxide, is up to 135 μc./mgm., corresponding to $\sim 3 \times 10^{11}$ disintegrations per gm. and per min. Using the gas counter, 3×10^{-11} gm. of this sugar, or the equivalent amount of its metabolites, can still be measured with reasonable precision.

Biosynthesis has also been used for making radioactive tobacco mosaic virus[10]. In the first experiments, the virus was made by exposing to radioactive carbon dioxide leaves which had been infected four months previously. Yields of virus—purified by repeated isoelectric precipitation, and tested by electrophoresis—were mostly around 0·1 per cent, referred to the weight of the fresh leaf. The specific activity of the virus was of the order of 0·1 per cent of that of the carbon dioxide used. The fact that the virus showed radioactivity indicates either that growth of the virus is still going on after this long period, or that the virus, at stationary concentration, still takes part in metabolism.

In a further set of experiments[11], the radioactive carbon dioxide has been offered to rapidly growing virus a few days after infection. It has been found that in a certain time interval the specific activity of the virus is independent of the 'age', that is, the time since infection, while the total activity increases with age. Both the specific activity and the total activity of 'young' virus exceed considerably that of 'old' virus in that interval.

Our colleague, Prof. O. Hromatka, has synthesized butter yellow (dimethyl amino-azobenzene) from radioaniline and inactive dimethyl aniline[12]. The material is being used by us jointly with Drs. W. Zischka and K. Karrer, of the Institute of Pathology of the University of Vienna, for determining the metabolism of this compound, which produces liver cancer in rats. After oral application of 3 mgm. in olive oil in a single dose, by probe, it is found that a fair amount of radiocarbon is absorbed by the liver, but is excreted again with surprising speed, that is, within some weeks.

O. Hromatka has also demonstrated, in a different study, that *Acetobacter* incorporates carbon from radioactive carbon dioxide during submerged vinegar fermentation. On the other hand, the acetic acid produced shows very faint radioactivity only. Possibly the active acid originates in a biochemical process different from the predominating process, that is, from the process of direct oxidation of alcohol[15].

Finally, Dr. K. Kratzl has shown in experiments on the biogenesis of lignin that growing plants (beans, spruce) incorporate radioactive coniferin. The coniferin was either implanted into the cambium or introduced through the roots. The absorption has been proved both by Geiger counting and by radioautography. The coniferin has been made[13,14] either from radioactive carbon dioxide by a Grignard type process or from active malonic ester, and is labelled in the 3- or 2-position, respectively. The findings lend support to the idea, put forward a long time ago, that coniferin is one of the main structural units of lignin.

Similar experiments are in progress with radioactive syringin and the glucoside of radioactive *p*-oxycumaric alcohol[16]. Along with coniferin, these glucosides are believed to be precursors of the lignins of angiosperm and especially of monocotyledonous plants.

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LETTERS TO THE EDITORS

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Effect of Molecular Weight on the Cross-linking of Siloxanes by High-energy Radiation

RECENT work has shown that many long-chain polymers[1,2] can be cross-linked by high-energy radiation; although polymers containing only carbon atoms in the main chain have been studied in great detail, the same effect has been observed in polymers in which the main chain comprises alternating carbon and oxygen atoms ('Carbowax') or silicon and oxygen (silicones). There is a considerable amount of evidence to show that for a given polymer the density of cross-linking (that is, the proportion of monomer units which are linked) is directly proportional to the radiation dose over a wide range. This renders it possible to prepare a series of samples of known (relative) densities of cross-linking. Absolute values of the density of cross-linking may be evaluated in a number of ways, including swelling measurements and determination of the minimum radiation needed to form an insoluble network or gel in a polymer of known average molecular weight.

Conversely, measurements on irradiated polymers may be used to study their average molecular weight and weight distribution. It may be shown theoretically that gel formation first occurs when there is present on the average one cross-link per 'weight average' molecule, while the subsequent shape of the gel fraction/cross-linking density curve is directly related to the molecular-weight distribution in the original polymer. If the cross-linking density is proportional to radiation dose but is independent of molecular weight (apart from very small end-effects) the radiation dose, R, needed to promote incipient gel formation in a number of polymers of similar structure should be inversely proportional to their weight average molecular weight, M.

Lawton, Bueche and Balwit[2] have found that in a number of polyethylene samples of varying molecular weights the radiation dose required for gel formation varies inversely as the 1·26 power of molecular weight, as against the value of 1 required by the above considerations. This would indicate that the density of cross-linking depends on molecular weight, even for long polymers. From the published data it is not clear that the molecular weights referred to are indeed the weight averages, and the results might be taken to show that the molecular weight distribution is different in the various polyethylenes studied. There is, indeed, some evidence that this is the case[3].

A much wider range of molecular weights can be studied in polysiloxanes, which are available as fluids of varying viscosities. The relation between viscosity and molecular weight has been studied by Barry[4]. It is therefore possible to study quantitatively the cross-linking efficiency (that is, the percentage of monomers cross-linked per unit radiation) as a function of molecular weight of these polymers.

Samples of polydimethylsiloxanes of various viscosities were irradiated in evacuated silica phials or in small aluminium cans, in similar positions in the B.E.P.O. atomic pile at Harwell, or in test-tubes at fixed distances from a radioactive cobalt-60 source of pure gamma-radiation, the radiation dose being proportional to exposure time. The minimum radiation dose needed to prevent melting at temperatures of up to about 200° C. was recorded; the transition from a fluid at 20° C. to one which is infusible even at these much higher temperatures is usually very sharp. Solubility measurements confirm that this change corresponds to the incipient formation of a gel structure.

The accompanying table summarizes the results obtained on a range of polydimethylsiloxane fluids. The viscosity η is given in centistokes at 25° C., and the corresponding average molecular weights M are obtained from smoothed curves of data given by Barry[4], while M' are average molecular weights calculated from a formula of Barry: $\log \eta = 1 + 0{\cdot}0123\, M'^{1/2}$. Two values of R are given for each fluid; the lower value corresponds to a dose when the irradiated sample is still fluid, and the latter when gel formation has proceeded to a sufficient extent for an infusible material to result. The radiation dose for incipient gel formation lies between these values.

It is seen that over the range of molecular weights 2,000 to 115 × 10^3, the product RM is constant to within experimental error, indicating that the radiation dose needed to produce an average of one cross-link per weight average molecule is inversely proportional to the number of units in the molecule. Hence the radiation required to cross-link a given proportion of the monomer units is independent of molecular length. Only for very short molecules, comprising but a few monomer units ($M \ll 0{\cdot}12 \times 10^{-4}$), does RM increase. This increase is not ascribed to end-effects, since it is not progressive; it probably arises from different production methods resulting in the presence of cyclic structures and a different molecular weight distribution. The published data show that for the higher polymers there is no great difference between number and weight-average molecular weight. For these polymers, unit pile radiation results in 2·3 cross-links per hundred monomer units, independent of the molecular weight. When account is taken of the relative weights per monomer (which determine in part the energy absorbed in the pile), this value is not very different from that deduced for polyethylene and similar saturated hydrocarbons cross-linked by pile radiation.

Table 1. MINIMUM RADIATION DOSE (PILE RADIATION)* FOR GEL FORMATION

Viscosity at 25° C. (η)	2×10^5	10^5	$12{\cdot}5\times10^3$	10^3	500	200	100	50	20	10	5	3
Molecular weight: (smoothed data), $M\times10^{-4}$	11·5	10·5	7	2·8	2	1·05	0·62	0·38	0·2	0·12	0·07	0·05
(calculated), $M'\times10^{-4}$	12·3	10·6	6·36	2·65	1·92	1·12	0·66	0·32				
Radiation dose (R)	0·025	0·03	0·05	0·10	0·15	0·3	0·53	0·8	1·85	4·8	8·5	9·9
(pile units)	0·03	0·035	0·055	0·11	0·17	0·32	0·58	0·81	1·92	5·3	9·5	11·4
$RM\times10^{-2}$	28·8	31·5	35	28	30	31·5	32·9	30·4	37	58	60	49·5
	34·5	36·7	37·5	30·8	34	33·6	36·0	30·8	38·4	64	67	57

* Unit pile radiation is an exposure corresponding to 10^{17} slow neutrons/cm.^{2}, plus the associated fast neutrons and gamma-rays.

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Jan. 4.

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Some Effects of Irradiation on Nylon and Polyethylene Terephthalate

In a detailed paper by Charlesby[1] on the effects of irradiation on polyethylene, he suggested that the main effect was 'cross-linking', that is, the formation of covalent bridges between neighbouring molecular chains, with the consequent loss of hydrogen. Since then, there has been a tendency to refer to the effect on any polymer as 'cross-linking' when low irradiation doses show changed solubilities in normal solvents, increased melting points, and no gross chemical breakdown[2], although other possible causes for these changes have been suggested[3]. It seems appropriate, therefore, to describe experiments on two of the polymers which have been specifically mentioned by Charlesby and Lawton, 66 nylon and 'Terylene'.

66 *Nylon*. Specimens of oriented 66 nylon were irradiated in B.E.P.O. with a dose of approximately 5×10^{18} n./cm.^{2}, together with the associated γ-radiation. This was fifty times the dose which first affected its solubility. Observations were that hydrogen was evolved as a gas at a rate which decreased as the dose increased. Groups of atoms were broken off and formed low-molecular weight compounds which could be extracted. On X-ray diffraction photographs of an oriented specimen, the crystallites (possibly 50 per cent of the whole) appeared to be unaffected. The strength of the irradiated material was lower than the original; but subsequent experiments have shown that complete loss of strength did not occur until after an irradiation dose sufficiently high to disrupt the crystallites.

On swelling in formic acid, diffraction photographs of the highly swollen nylon showed that the crystallites had entirely disappeared, so that the nylon together with formic acid could either have been a two-phase system, or else the nylon molecules were held together with a few loose covalent bridges. On washing with water and drying, new unoriented crystallites were formed. The degree of crystallinity was less (about 30 per cent possibly), while the intensities and spacings of the diffraction rings were consistent with the new crystallites being methyl-substituted nylon. This unoriented nylon could be oriented by stretching the specimen by an amount similar to that required to draw normal unoriented nylon. On putting the irradiated nylon, which was already highly swollen in formic acid, in a mixture of formic acid with a few per cent of hydrochloric acid, immediate solution took place (under these conditions neither peptide bonds nor —CH_2—CH_2— bonds would be broken). After reprecipitation in water, the polymer had the same properties, and on casting a film rather less than 200 A. in thickness for examination in the electron microscope, it was found that the densities of the crystalline and non-crystalline regions were practically the same—as would be expected for an alkyl-substituted polyamide.

On irradiation of 66 nylon in the presence of air, there was a rapid loss of strength, and an analysis by British Nylon Spinners Ltd., showed a very considerable increase in —COOH end-groups (private communication).

Polyethylene terephthalate. The behaviour of polyethylene terephthalate (or 'Terylene') is completely different. To begin with, hydrogen and other gases are not evolved in appreciable quantities. Specimens of polymer chips and fibre were irradiated with approximately $1{\cdot}5 \times 10^{18}$ n./cm.^{2}. After this dose the fibres had completely lost their strength and begun to powder, while the chips were brittle. In specimens which were originally well crystalline the diffraction patterns looked much the same. This may be contrasted with the behaviour of 66 nylon. One polymer specimen was irradiated which had been prepared in an almost completely non-crystalline condition, and after irradiation the chips were still non-crystalline. They were then annealed at 140° C. for 1 hr., after which X-ray diffraction showed the pattern of normal well-ordered polyethylene terephthalate. This suggests (*a*) that extensive bridge formation could not have occurred, since any such tight linkage would inhibit the movement of molecules relative to one another, and (*b*) that a large number of side-groupings did not occur, since they would have shown in the diffraction pattern. The results are consistent with a straightforward breakdown of the polyethylene terephthalate chains, the breakdown products having sufficient rigidity to maintain their original positions to a fairly large extent.

End-group analyses by Imperial Chemical Industries, Ltd. (private communication), have shown an interesting difference, according to whether irradiation breakdown took place in the presence or absence of air. In the absence of air, there is a large increase in the number of —COOH end-groups, whereas in the presence of a plentiful supply of air the extra end-groups were found to be —OH and C=O, as in an aromatic aldehyde or ketone. This suggests that the molecular chains break in different places in the two cases.

I wish to thank British Nylon Spinners Ltd., and Imperial Chemical Industries, Ltd., for providing samples of polymers.

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Feb. 11.

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High-energy Microturbulence in the Solar Photosphere

The Balmer, Paschen and Brackett lines of hydrogen in the solar spectrum are much wider than they should be according to computations based on the classical widening mechanism of the hydrogen lines[1]—the statistical Stark effect of the ions surrounding the emitting atoms. The amount of widening is

greater for the Paschen than for the Balmer lines; it is greatest for the Brackett lines. It seems impossible to ascribe this widening to atomic processes, since Jürgens[2] has shown in elegant laboratory experiments that the profile of H_β is explained by the statistical Stark effect of the ions. Hence, the abnormal widening of the hydrogen lines must be explained by a mechanism which is active in the solar photosphere but not in laboratory experiments. It is difficult to ascribe it to super-excitation since the wings of the hydrogen lines are formed in rather deep parts of the solar photosphere, where deviations from thermodynamical equilibrium are not very likely to occur. It can be shown that the widening is probably explained by the microturbulence of the solar photosphere, a mechanism suggested to me by Prof. A. Unsöld, of Kiel.

Computations of the profiles of the hydrogen lines have been made for two turbulent models of the photosphere. In the first, the solar photosphere is supposed to be composed of many thin vertical columns, all with the same base areas. They are evenly distributed over the solar surface, and half of them have high temperatures, the others have low temperatures. One ray of light passes through only one column, although the spectrum is made up from the composite effect of all these columns. At an optical depth τ the temperatures in these columns are given by

$$\theta_1(\tau) = \theta_0(\tau) + \Delta\theta$$
$$\theta_2(\tau) = \theta_0(\tau) - \Delta\theta \quad (\theta = 5{,}040/T\ (^\circ\text{K.}))$$

The function $\theta_0(\tau)$ is for a non-turbulent model—my model VII (*l.c.*, ref. 1). We have adopted the same relation between τ, P_g and P_e as in model VII. It is provisionally assumed that $\Delta\theta$ does not vary with depth.

The profiles of the wings of four Balmer lines, seven Paschen lines, and six Brackett lines have been computed for the centre of the solar disk for this turbulent model, and for four values of $\Delta\theta$; after that a comparison of the computed profiles with the observed ones gives by interpolation an empirical determination of $\Delta\theta$. We obtain $\Delta\theta$ values ranging between about 0·05 and 0·15, but the values seem to depend slightly on the depth of formation in the solar atmosphere. Since for each point on a line profile a 'mean optical depth of formation' can be computed, we may plot the empirical $\Delta\theta$ values against the

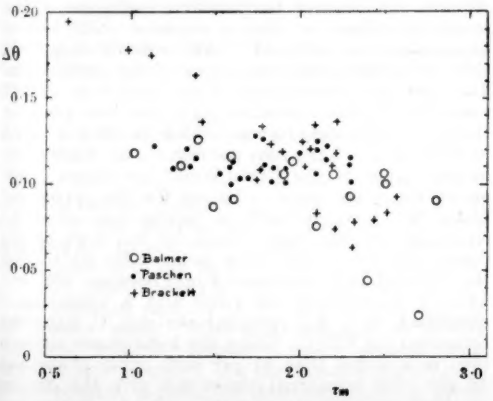

Fig. 1

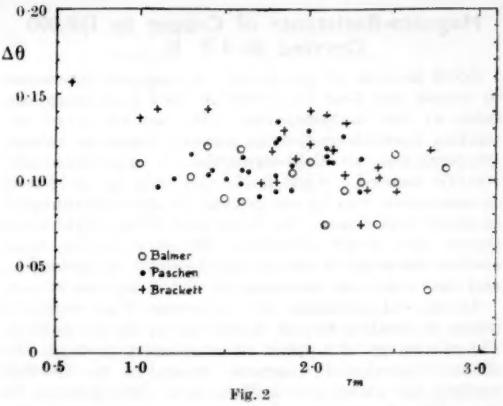

Fig. 2

corresponding mean τ-values (τ_m) in order to check whether $\Delta\theta$ varies with depth. The results are shown in Fig. 1, where τ is the monochromatic optical depth for 5000 A. It seems that $\Delta\theta$ decreases slightly with increasing τ_m.

In the second turbulent model, it is assumed that the solar photosphere consists of many small volume elements, half of them with $\theta_1(\tau)$, the others with $\theta_2(\tau)$, distributed at random. One ray of light passes through many elements of both kinds. Here again we have adopted the same relation between τ, P_e and P_g as in model VII. The computations proceeded in an analogous way as for the first model, and the resulting $\Delta\theta$ values, plotted against τ_m, are given in Fig. 2. Here also it seems that $\Delta\theta$ depends on τ_m, but the dependence is less clear than in Fig. 1.

Both graphs show the same general aspect. It is gratifying to notice that there are no systematic differences between the points which result from the three hydrogen series. The scatter of the points is of the order of $\pm$ 0·015 in $\Delta\theta$. This corresponds with errors in the computed line profiles of $\pm$ 2 per cent (expressed in the intensity of the continuous spectrum). Since this latter value is about equal to the photometric errors in the observed line profiles, it is concluded that microturbulence is probably responsible for the additional widening of the solar hydrogen lines.

The main result of this investigation is that the temperature fluctuations in the solar photosphere are of the order of $\Delta\theta = \pm$ 0·1 between $\tau = 1$ and 2·5. At $\tau = 1$, $T = 6{,}500°$, giving $\Delta T = \pm$ 850°; and at $\tau = 2{\cdot}5$, $T = 7{,}200°$ and $\Delta T = \pm$ 1,000°. It has already been suggested by me[1] that the difficulties in establishing a model of the chromosphere could be solved by a 'two-temperature model'. We now find that this is probably also the case for the photosphere.

If the very great temperature fluctuations found here are confirmed by computations based on other Fraunhofer lines and on the continuous spectrum, it will be necessary to modify greatly present views on the structure of the solar photosphere.

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Magneto-Resistance of Copper to 150,000 Oersted at 4·2° K.

Some aspects of the theory of magneto-resistance in metals can best be tested in very high magnetic fields at low temperatures[1]. We are therefore extending magneto-resistance measurements at helium temperatures to field-strengths of approximately 150,000 oersted. Such fields can only be produced at reasonable cost by employing Kapitza's technique[2] of short field pulses. De Haas and Westerdijk[3] have shown that much improved efficiency results from cooling the magnet coil in liquid helium or hydrogen, and this has been discussed in detail by one of us[4].

In our experiments the specimen was mounted inside a small solenoid immersed in liquid helium. The discharge of a bank of condensers through the solenoid produced magnetic fields up to 160,000 oersted for about one millisecond. The current in the solenoid, and the voltage generated across the specimen by an alternating measuring current of frequency about 10 kc./s., were presented on the screen of a double-beam oscillograph.

Fig. 1 shows the resistance change $\Delta R/R$ for commercial copper wire of diameter 0·1 mm.; residual resistance $R_{He}/R_{Ice} = 0{\cdot}89$ per cent. One specimen was wound helically to be exposed to a transverse field. The other was placed mainly parallel to the field with approximately 15 per cent of its length at right angles to it. The error due to skin effect is less than a half per cent.

Grüneisen and Adenstedt[5] have made measurements on a single-crystal specimen of copper of approximately ten times lower residual resistance in fields up to 12,000 oersted. Our transverse results are consistent within about 30 per cent with their measurements in the direction of greatest change of resistance if Kohler's rule that $\Delta R/R$ is a function of (H/R) is correct. No comparable data are available for the longitudinal case. Our results thus provide a test of Kohler's rule in a region of magnetic field where there have hitherto been no measurements.

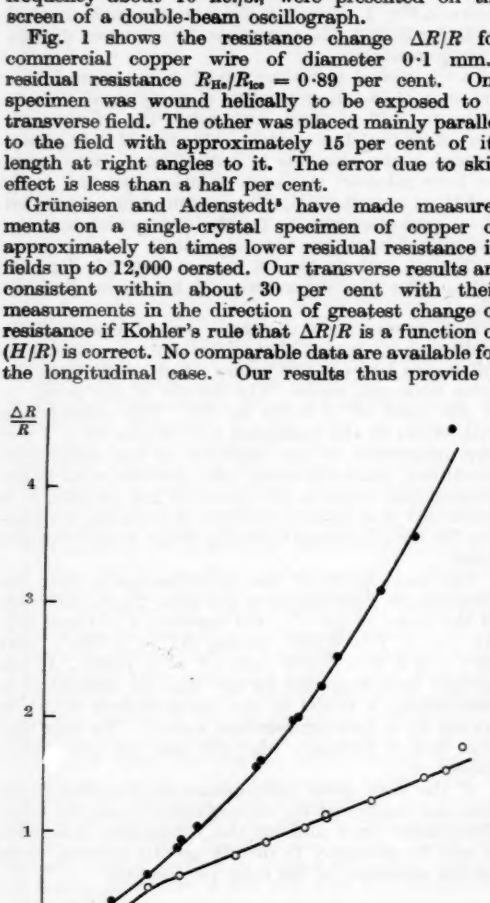

Fig. 1. Variation of electrical resistance with magnetic field in copper at 4·2° K. O —— O, longitudinal field; ● —— ●, transverse field

We are grateful to Prof. P. Grassmann for his encouragement and interest.

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Anomalous Temperature Coefficient of Permittivity in Barium Titanate

While engaged in tests on the 'ageing' of the permittivity of a sample of ceramic barium titanate, an observation was made which may be of interest in connexion with the theory of this substance. The sample was held at a temperature of 125° C., about 1° below the Curie point through which the sample had just been cooled. It was found that the temperature cycling due to the operation of the thermostat caused the capacitance of the sample to cycle in the opposite sense, that is, a negative temperature coefficient was observed, whereas the normal permittivity curve has, of course, a high positive slope just below the Curie point. A phase lag between the switching of the thermostat and the sample temperature was at first suspected; but a test made with a thermocouple clamped to the specimen and the on–off cycle very much slowed down gave the same result.

It is well known from X-ray diffraction work[1,2] that for a few degrees near the Curie temperature the cubic and tetragonal phases of barium titanate can co-exist in the same crystal. It now appears that a quite finite increment in temperature is needed to change the proportions of cubic and tetragonal material, for the effect described is easily explained by postulating that this ratio remains constant during the small temperature fluctuations (0·1° C.) due to the thermostat. The relatively high negative temperature coefficient of the cubic phase swamps the positive temperature coefficient of the tetragonal phase, so that a negative coefficient of capacitance is observed. An order-of-magnitude calculation shows the plausibility of this explanation. The measured permittivity of the sample at 125° C. was 4,100, while the permittivity of the cubic phase at this temperature and its temperature coefficient would be 6,600 and − 5 per cent per deg. C., as obtained by extrapolation of the Curie–Weiss law which holds above the Curie point. Values for the tetragonal phase are more difficult to extrapolate since no empirical law has been found for the part of the curve just below the Curie point. By continuing the slight upward curvature found between 105° and 118°, a permittivity of 2,200 and a temperature coefficient of + 3·5 per cent per deg. C. has been estimated for 125° C. Using the logarithmic mixture law, it is found that 55 per cent cubic phase and 45 per cent tetragonal phase will give the correct resultant permittivity of 4,100. The resultant temperature coefficient calculated with these proportions

is then − 1 per cent per deg. C. The value found experimentally was about − 1·4 per cent per deg. C.

The question of whether the transition at around 120° C. is of the first or second order was still open recently[2], although several papers have now appeared reporting in favour of a first-order transition[4,5]. The finite temperature change (of very roughly 0·3 deg. C.) which we found necessary to cause the transition to occur may be interpreted as a further argument in favour of a first-order transition; for temperature hysteresis due to the need to activate the system over a free energy barrier is a well-known feature of first-order transitions.

It may be argued that internal strains of the ceramic are causing the observed effect, which may be likened to a mechanical yield-point phenomenon. Nevertheless, any explanation based on a second-order transition would be difficult, since the structure would be changing continuously and so the permittivity should also change continuously.

It should be mentioned that the barium titanate used was particularly pure[6]. The sample had been fired in a uniform temperature enclosure and cooled slowly from the firing temperature to minimize internal strains.

Thanks are due to British Dielectric Research, Ltd., for permission to publish this note.

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Pore-Size Distribution of Porous Iron

Ritter and Drake[1] have proved the usefulness of measuring the penetration of mercury under pressure, in order to elucidate the pore-size distribution of various substances. From elementary theory, it follows that for the radius r_p of pores filled at a pressure p:

$$r_p = \frac{-2\sigma \cos\theta}{p}, \qquad (1)$$

where σ is surface tension and θ is contact angle. Substitution of $\sigma = 480$ dyne/cm. and $\theta = 140°$ gives:

$$r_p = \frac{75{,}000}{p} \text{ A. } (p \text{ in atm.}).$$

Thus, measuring up to pressures of about 1,000 atm., the method is especially suited for the determination of the distribution of pore sizes greater than 100 A. In this range other methods, based on the application of the Kelvin equation to gas adsorption and desorption data, present many difficulties[2].

Two different samples of porous iron were used in the present study. The first consisted of tablets (diameter, 5 mm.; height, 4 mm.), pressed from carbonyl-iron powder; the particle-size distribution of the powder, determined microscopically, is given in Table 1.

Table 1

Range (μ)	Per cent (by weight)
0–1	2
1–2	4
2–3	7
3–4	9
4–5	14
5–6	19
6–7	26
7–8	10
8–9	5
9–10	3
>10	1

The second sample was obtained by reduction of a doubly promoted iron catalyst for ammonia synthesis. The catalyst contained 3 per cent of aluminium oxide and 1 per cent of potassium oxide before the reduction. The reduction was performed in a stream of pure hydrogen for 70 hr. at 450° C. As mercury shows a tendency to wet the surface of a freshly reduced iron catalyst, the sample was made passive in a stream of hydrogen containing about 0·1 per cent oxygen[3] for 48 hr. at room temperature.

The total pore-volume of both samples was calculated from the difference of specific volumes in helium and mercury. The surface areas were determined from the adsorption isotherm of nitrogen at − 196° C., following the Brunauer–Emmett–Teller method for the evaluation of the monolayer capacity (for the molecular area of nitrogen 16·2 A.^{2} was used). The results are given in Table 2 (cols. 1 and 2).

Table 2

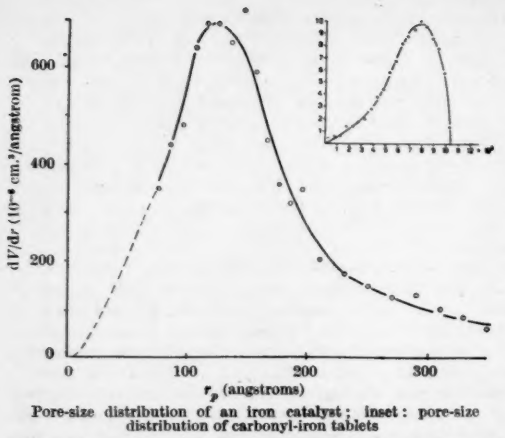
	1	Surface area (m.^{2}/gm.) 2	3	4	5	6
	Pore volume cm.^{3}/gm.	B.–E.–T.	Calculated from pore-size distribution	Calculated from particle-size distribution	$\bar{r}_V = \frac{2V}{F}$ A.	$r_{max.}$ A.
Carbonyl iron	0·051	0·21	0·15	0·18	5000	8000
Iron catalyst	0·116	13·1	15·1	—	177	120

The mercury penetration was measured in an apparatus as described by Ritter and Drake[1]. The maximum pressure obtainable was 1,100 atm. From a plot of the mercury-filled volume versus pore-radius, it appeared that the total pore volume of the carbonyl-iron tablets was completely filled at a pressure corresponding to a pore-radius of about 1000 A. In the case of the iron catalyst, however, about 10 per cent of the pore volume remains empty at the highest pressure obtainable. The distribution curves, $\frac{dV}{dr}$ (r), given in the accompanying figure, were calculated by graphical differentiation of the experimental curves.

To check the results, the surface area (F) was calculated from the distribution curves with the help of the formula:

$$F = \int_0^{\infty} \left(\frac{dF}{dr}\right) dr = \int_0^{\infty} \frac{2}{r}\left(\frac{dV}{dr}\right) dr.$$

The values found are given in Table 2, col. 3, and compare well with the Brunauer–Emmett–Teller values calculated from gas adsorption data and, for the carbonyl-iron, also with the value calculated



Pore-size distribution of an iron catalyst; inset: pore-size distribution of carbonyl-iron tablets

from the particle-size distribution (from microscopic inspection the particles appeared to be spherical).

Col. 5 of Table 2 gives the values of the mean pore-radii calculated in the usual manner by dividing twice the pore volume by the Brunauer–Emmett–Teller surface area ($\bar{r}_p = 2V/F$). These values deviate from the pore radius at the maxima of the distribution curves (col. 6), which is due to the non-symmetrical form of the distribution curves.

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Influence of Electronic Impact on the Rate of Sorption of Gases on to Getter Materials

The observations by Reimann[1] and Lukirski and Ptizyn[2] showed that the low rates at which some gases (carbon monoxide, nitrogen and hydrogen) are sorbed by magnesium getters can be increased considerably if the gas molecules are converted into other particles (for example, atoms or ions) by the impact of electrons. The view that this phenomenon is a general one, also existing with other getter and gas combinations, has been supported by some experimental evidence. Haase[3], for example, who was the first to use a Knudsen gauge for investigation of getters, observed that barium getters only sorbed gas at pressures between 10^{-5} and 10^{-6} mm. mercury if the getter deposit was prepared with extreme care from barium distilled *in vacuo* three times and afterwards evaporated at the very low pressure of 10^{-8} mm. Even under these stringent conditions, the gettering-rates obtained were of the order of only 10 cm.³/sec. for a getter area of 120 cm.². This result appeared to show that gettering-rates of the order of 1,000 cm.³/sec., as observed when measuring with ionization gauges at such low pressures[4], are mainly due to the electron impact occurring in those gauges.

Recently I have had an opportunity of using a Knudsen gauge (for the loan of which I am indebted to Messrs. W. Edwards, Crawley, Sussex) in combination with my flow method by which gettering-rates can be measured directly[4] instead of deriving them from pressure–time curves. The results obtained have shown that, contrary to expectations, electron impact has little influence on the properties of barium getters.

The experimental arrangement used for these measurements was similar to that described earlier[4], the only difference being that the ionization gauge on the far side of the capillary (right-hand side of Fig. 1, ref. 4) was replaced by the Knudsen gauge, which had a sensitivity of 3×10^{-3} mm. mercury/mm. scale. To this gauge a side tube of 30 mm. diameter was connected in which the getter and the diode used for producing the electron impact were located. The total volume on the far side of the capillary was about 1 litre.

For pumping, a single-stage and a two-stage diffusion pump in series were used. These were operated with silicone oil, omitting any liquid-air traps. After the glass equipment had been baked for between one and three hours, a pressure of about 1×10^{-7} mm. was measured in the Knudsen gauge. Immediately after the bake, gas adsorption on the glass surfaces (total area about 1,000 cm.²) was tested. Using a pressure of 5×10^{-5} mm. on the pump side of the capillary, this adsorption came to an end after 30 sec., while sorption obtained under the same conditions by a barium getter (area 8 cm.²) was detectable for about an hour.

The barium getters were deposited from *KIC*-getter wires at pressures between 10^{-5} and 10^{-4} mm. During measurement of gettering-rates, the pressure above the getter was between 10^{-7} and 10^{-6} mm. The electron impact was generated in a diode consisting of either a tungsten or tantalum cathode and an anode made from either nickel or tantalum sheet, located at a distance from the cathode varying between 5 and 35 mm. The anode voltage was 100 V., and the electron current about 10 m.amp. The influence of the hot cathode alone on the value measured for the rate of sorption was negligible with carbon monoxide and oxygen, but of considerable magnitude with hydrogen ($\simeq$ 500 cm.³/sec.).

As shown in the accompanying table, high gettering-rates were obtained in the systems barium – oxygen and barium – carbon monoxide without any electron impact. It was carefully checked that these high rates were neither due to, nor influenced by, the electrons passing in the ionization gauge in the manifold (left-hand side of Fig. 1, ref. 4) or by the potential across the heater of the Knudsen gauge (10 V.).

During the experiments, the getters were kept at different temperatures in the range 50°–220° C. Within the accuracy of the measurements a temperature dependence of the gettering-rate could not be detected, which means that this dependence was equal to or less than 10 per cent for barium – carbon monoxide and equal to or less than 2 per cent for barium – oxygen. From the latter value it can be

Influence of Electron Impact on Gettering-Rates (in cm.³/sec.)

Getter	Gas	Getter area (cm.²)	Number of measurements	Average value of gettering-rate without impact	Average value of gettering-rate with impact
Barium	Oxygen	6	7	1,200	1,250
,,	Carbon monoxide	6	5	1,800	1,800
,,	Hydrogen	6	3	50	not measured
Magnesium	Carbon monoxide	30	2	7	12

concluded that the appropriate activation energy is smaller than 0·05 k.cal./mole. These activation energies are much smaller than those measured by Arizumi and Kotani[5] and Kobayashi and Furaya[6] at higher pressures (5–8 k.cal./mole).

Acknowledgment is made to the Engineer-in-Chief of the General Post Office for permission to make use of this information. I also wish to thank Mr. R. E. Thorne and Mr. J. H. Phippen for their assistance in the experiments.

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Preparation of Dephosphorized Casein by an Enzymic Method

Plimmer and Bayliss[1] showed as early as in 1906 that the phosphorus of casein could be completely removed as inorganic phosphate by the action of 1 per cent sodium hydroxide at 37° C. in 24 hr. Acidification of the digest after the completion of dephosphorylation precipitated a substance resembling casein. Rimington[2] analysed the dephosphorized casein for its nitrogen distribution and noticed little difference in composition from that of casein except in amide and arginine nitrogen. The low values obtained in these two cases were evidently due to the hydrolytic action of alkali on these compounds with the production of ammonia. Plimmer and Lawton[3] found besides that by the action of *N*/4 alkali on casein there was formed in addition to casein a substance or mixture of substances resembling a primary proteose. The use of alkali as a dephosphorylating agent was considered to be undesirable for these reasons.

Enzymic methods have come into vogue recently in studies of this type. The preparation of dephosphorized phosvitin by Mecham and Olcott[4] and of phosphorus-free ovalbumin by Perlmann[5] deserves special mention in this connexion. In the present investigation a purified preparation of phosphoprotein phosphatase obtained by us from ox spleen[6] has been used for the preparation of dephosphorized casein. For the preparation of the protein the following method has been adopted.

1 litre of the digest containing 25 gm. of casein, 25 ml. of the pure enzyme preparation (283·5 phosphatase units per mgm. of protein nitrogen) and thioglycollic acid (activator) to a final concentration of 0·001 *M* was adjusted to a *p*H of 6·0 by veronal–acetate buffer. At the end of 24 hr. incubation at 37° C., a further quantity of enzyme preparation (10 ml.) was added to the digest. A precipitate had begun to separate by this time. When there was no more increase in the liberation of inorganic phosphorus (96 hr.) the precipitated protein was separated on the centrifuge, washed repeatedly with water and finally with acetone. The air-dry product weighed 16·5 gm.

The protein is a white amorphous powder lighter than casein. It is relatively insoluble in water. It is, however, soluble in dilute alkali and its solubility in dilute acids is greater than that of casein. It can be precipitated from its alkali solution by acidifying to *p*H 6·0. There seems to be thus a shift in the isoelectric point of casein to the alkaline side during its dephosphorylation, presumably due to the removal of the phosphoric acid groups.

The protein has a nitrogen content of 15·7 per cent and contains about 0·03 per cent of phosphorus. Its content of arginine, histidine, cystine and tryptophan as determined by standard chemical methods resembles closely that of casein. No drastic changes appear to take place during enzymic dephosphorylation. The protein has also been found to be readily attacked by proteolytic enzymes. Alkali-dephosphorylated casein is attacked by these enzymes with difficulty[3], possibly due to some racemization having taken place during alkali treatment. The lowering in nitrogen content brought about by alkali is another serious defect in the use of this reagent as a dephosphorylating agent. Since these drawbacks are eliminated by enzymic dephosphorylation, phosphoprotein phosphatase should prove to be a useful tool in studies on dephosphorylated proteins.

The complete amino-acid make-up of the protein is under investigation, and details of this work will be published elsewhere.

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"Role of Plasmagenes"

In Prof. C. H. Waddington's review of the book by Boris Ephrussi, "Nucleo-cytoplasmic Relations in Micro-organisms"[1], the major adverse criticisms do not, in my opinion, stand up to close examination.

First is the imputation that Ephrussi does not understand, or at least recognize, that "A property of genetic continuity is attributed to both nuclear genes and plasmagenes, but the evidence for it is of quite different, in fact almost opposite, nature in the two cases. Nuclear genes are considered to exhibit genetic continuity because they continue in existence throughout lengthy series of crosses, etc., whereas the evidence for the continuity of plasmagenes is the fact that if they are got rid of they cannot be regenerated". Now the fact is that, whereas nuclear genes and plasmagenes have been detected on the basis of somewhat different criteria, their common attribute of genetic continuity is based on essentially the same properties and observations. In so far as present knowledge permits the definition of plasmagenes and nuclear genes, Waddington might have more soundly compared them along the following lines, which would have led to a quite different approach to the point at issue.

(1) Neither a nuclear gene nor a plasmagene is recognizable unless found in differential states of activity and inactivity, or presence and absence.

(2) Both are considered to exhibit genetic continuity because they continue in a lengthy series of cell generations over which some characteristic referring back to the 'gene' is faithfully recurrent.

(3) So far as one really knows, neither can be regenerated.

(4) The two types of genes are distinguishable because in sexual reproduction nuclear genes follow precise segregational patterns based on chromosomal mechanics while cytoplasmic genes do not.

(5) The criteria and the experimental means for the detection of plasmagenes require much more careful consideration than has usually been given them in the past. (This point has often been ignored by geneticists but is critically treated by Ephrussi on pp. 116–118 of his book.)

Second is Waddington's objection that bringing plasmagenes into play to explain differentiation leads to confusion. His argument is that "Either the plasmagenes arise *de novo* during development, in which case they are doing exactly that thing the impossibility of which is used as a means of detecting them; or they are all present, possibly in an inactive form, in the unfertilized egg, in which case they are nothing but our old and discredited friends the 'organ-forming substances' appearing under a new name and with their hair curled in the latest fashion". In all fairness, it should have been pointed out that any difficulties in the interpretation of differentiation that arise out of the second alternative apply to nuclear genes as well as plasmagenes.

Third, in the final paragraph of the review, Waddington states: "True, he [Ephrussi] starts off on the wrong foot, arguing rightly enough (on p. 4) that development involves a 'differential [which] must have its seat in the cytoplasm', but drawing the complete *non sequitur* that 'if the cytoplasm causes differentiation it must be endowed with the power of perpetuation of cell-type' ". This statement of *non sequitur* is based on the quotation of two isolated fragments taken out of context, and appears to me to be a serious misrepresentation of Ephrussi's position. Actually, in the text, both before and between the two fragments quoted in the review, there is important material that establishes the general line of argument. Essentially this material is in reference to highly significant experiments in tissue culture, which show that differentiated cell types may breed true indefinitely. *Non sequitur* implies that a conclusion has been drawn fallaciously from irrelevant premises. Reference to the text clearly shows that Ephrussi has not been guilty of such an error, since his statement in question is not derived from the purported premise but is reasonable interpretation of a set of investigational observations that are under discussion.

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I welcome the opportunity to try to clarify a little further the difference of opinion between Prof. Srb and myself, which concerns rather the question of how the 'plasmagene' theory should be incorporated into general biological thought than the particular instance of Ephrussi's book, as to the high value of which we both agree, though it seems from different points of view.

The point I wished to make in my review was that many approaches to the 'plasmagene problem' seem to me to take it back-to-front. Thus Srb himself suggests that we should start by defining plasmagenes; he gives four points which say in effect that they are just like nuclear genes except that they happen to lie in the cytoplasm; and it is only in his fifth and last that he raises the "criteria and the experimental means for the detection of plasmagenes", which to my mind is a demure way of hinting that quite possibly no such entities as have been defined exist at all. I believe that a more useful method of discussion would be to start from the empirical facts and proceed cautiously towards the definition.

Prof. Srb's second paragraph does not persuade me to change my opinion that it is more difficult to account for a process of change (of cell-type during differentiation) in the face of two sets of persistent entities (genes and plasmagenes) than of only one set. As to the two quotations referred to in his third paragraph, they are both taken from p. 4 of Ephrussi's book. The two sentences which separate them rather tend to reinforce than to contradict the possibility that the persistence of differentiated cell-types is due more to irreversible nuclear changes than to cytoplasmic determinants; and they certainly do not refer to the tissue culture evidence, which in any case does not prove the point one way or the other.

I am glad to reiterate the point with which I ended my review. The great merit of Ephrussi's book is that, starting by an exposition of the arguments which have led many people to suggest that the idea of plasmagenes gives us a simple explanation of development, he comes at the end to advocate the more cautious and empirical approach. His discussion, in the Addendum to the main body of the book, of the criteria for the recognition of plasmagenes (to which Srb refers) is particularly valuable; but the whole progression of his thought is, as I hope I sufficiently emphasized, of the greatest interest, and makes his book one of outstanding importance in the history of these questions, which are among the most fundamental with which biology is concerned at the present time.

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Are Inbred Strains Suitable for Bio-assay?

Grüneberg[1] has directed attention to two properties of inbred strains which should counsel caution in their use for some experimental purposes: (1) They cannot be relied upon to remain constant in their heritable properties with the passage of time, and may diverge quite rapidly when split up into separate sub-strains and colonies. (2) They do not constitute phenotypically uniform material, but may, on the contrary, be strikingly more variable than the F_1 hybrids between strains.

This second proposition, for which Livesay[2] obtained experimental evidence in 1930, calls into question the established practice of using inbred material for the bio-assay of food factors, hormones, drugs, poisons, pathogens, etc. In such experiments precision in the estimates, and hence uniformity in the test organisms, is of the highest importance.

The characters measured in bio-assay are of the type usually termed 'physiological', whereas the

Exp.	Stock	Gm. 'Nembutal' per cent	Mean log response time	Antilog (min.)	Sums of squares	Degrees of freedom	Estimate of variance
I	Inbred	0·65	1·412	26	0·4896	13	0·0377
	F_1 hybrids	0·65	1·125	13	0·1827	8	0·0228
	"Mousery"	0·65	1·662	46	0·4853	13	0·0373
II	Inbred	0·65	1·593	39	0·8888	9	0·0988
	F_1 hybrids	0·85	2·110	129	0·2394	16	0·0150
	"Mousery"	0·65	2·185	153	0·5891	13	0·0453
Combined	Inbred				1·3784	22	0·0627
	F_1 hybrids				0·4221	24	0·0176
	"Mousery"				1·0744	26	0·0413

examples cited by Grüneberg all relate to morphological variation. None the less, the interpretation of the phenomenon advanced by Robertson and Reeve[2] and by Rasmuson[4] would imply that we are dealing with a general biological law which must be expected to apply no less to 'physiological' than to 'morphological' characters. "The more heterozygous individuals," write Robertson and Reeve, "will carry a greater diversity of alleles, and these are likely to endow them with a greater biochemical versatility in development. This will lead to . . . a reduced sensitivity to environmental variations, since there will be more ways of overcoming the obstacles which such variations put in the way of normal development."

Two experiments on variation in a 'physiological' character have, in fact, just been published. Yoon[5] has found in mice that F_1 hybrids are less variable in time of vaginal opening than the parental strains. Maynard Smith and Maynard Smith[6] working with *Drosophila subobscura* have found a decreased variability in rate of development associated with heterozygosity for a marked chromosome.

We have recently conducted experiments with mice on the variation of a character chosen to be of the type measured in bio-assay, namely, the duration of narcosis following the intraperitoneal injection of 0·10 ml. per gm. body-weight of a dilution of a proprietary preparation ('Nembutal') of pentobarbital sodium.

We compared the variability in response of samples of three stocks of mice: inbreds from the *C57BL* strain, F_1 hybrids from *C57BL* ♀ × *C3H* ♂ crosses, and random-bred albinos supplied by "The Mousery", Rayleigh, Essex. Unfortunately, it was not possible to include a sample of the other parental strain (*C3H*). The duration of narcosis was expressed as the logarithm of the number of minutes elapsing from the abolition to the reappearance of the righting reflex. The logarithmic transformation was adopted in order to eliminate dependence of the variance upon the mean, and was found to be satisfactory for this purpose.

There were indications of differences in response both between the sexes and among different litters. In order to eliminate these sources of variation, the variances were estimated from the within-sexes within-litters sums of squares.

Two similar experiments were done on two separate occasions. On each occasion the three groups of mice were tested concurrently. In the second experiment, the hybrids were given a larger dose to compensate for their greater resistance to the drug. All mice were in the age-range 4–7 weeks, and those belonging to the same group in the same experiment were always born within the same eight days. The results of the two experiments were in substantial agreement, and are set out in the accompanying table.

It will be observed that the variance of the response is about three and a half times as great in the inbreds as in the hybrids. The difference is statistically highly significant, as judged by the z-test ($P<0·01$). In terms of a hypothetical bio-assay experiment, three and a half times as many of the inbred as of the hybrid mice would have to be used in order to obtain results of the same accuracy.

More surprisingly, although the "Mousery" mice are as expected more variable than the hybrids, they are not more variable than the inbreds. On the contrary, the inbreds are more variable by half as much again. This difference, although not formally significant, should be regarded as suggestive, since the variability of the "Mousery" mice was almost certainly over-estimated in this experiment. It was not known which of these mice were litter mates. Hence the sum of squares used to estimate their variance includes a component which was eliminated in the analysis of the other two groups, namely, that due to differences between litters.

A more clear-cut indication that genetically heterogeneous random-bred mice may sometimes be less variable than inbred material was obtained as early as 1939 by Emmens[7], who compared the variability of response to œstrone of a sub-strain of the *CBA* inbred strain of mice with that of a random-bred mouse colony. The variance of the inbreds, derived from the slope of the probit dosage – response curve, was about two and a half times that of the random-bred mice, and the difference was statistically highly significant.

Whether random-bred material is more or less uniform in a given case than inbred will, of course, depend upon circumstances which include the particular character which is measured and the genetical composition of the stocks which are compared. As regards the latter, the issue will be largely decided by the balance between the greater genetic variability among the random-bred organisms, making for phenotypic variability, and their greater heterozygosity, making for phenotypic uniformity.

The evidence suggests that the widely adopted policy of using inbred strains for bio-assay may be a mistaken one, and that inter-strain F_1 hybrids are to be preferred. Such material combines the genetic uniformity of inbred strains with the 'buffering' action against environmental variations which heterozygosity exerts.

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Occurrence of *Chthamalus stellatus* (Poli) in Fair Isle and Shetland

The Mediterranean/Atlantic littoral barnacle, *Chthamalus stellatus* (Poli), is at the northern limit of its range in Britain, and is confined to the south-west, west and north coasts. In the English Channel it is not recorded east of Swanage[1,2] and Flamanville; but there are a few old records for two places far beyond these limits—at and near Heligoland (recorded several times during the nineteenth century[3], but stated to be absent by more recent authors), and in the harbour at Anholt in the Kattegat (present March 1913, but absent in 1934[4]). The most northerly records to date are those for north-east Scotland[1] (confirmed during 1951 by Dr. J. R. Lewis and me), where the species is finally represented only by sparsely scattered, but well-developed, individuals; Stephensen's record for "Norway, S. of Lofoten"[5] would appear to be in error.

It is therefore of interest to record the presence of *C. stellatus* on the mainland of Shetland, as well as on Fair Isle, during June 1952; in all cases *Chthamalus* occurred above a belt of *Balanus balanoides*:

1. *Shetland* (June 24): *Chthamalus* scarce on the only exposed coast examined, in the south-west of the mainland (in Muckle Sound, just north of Spiggie Voe; position 59° 56′ 46″ N., 1° 20′ 32″ W.). Eleven of the larger barnacles were collected, and measured as follows: mean rostro-carinal length 7·6 mm. (range 4·8–10·0 mm.); mean breadth 6·7 mm. (4·5–9·5 mm.). Only three of these specimens were growing sufficiently close together to have been capable of cross-fertilization, and only these contained early-stage embryos.

2. *Fair Isle*: a number of coasts were examined, but *Chthamalus* was found only at the following two exposed places: (i) east coast (June 25)—scarce, at tip of headland (Landberg) on east flank of Mavers Geo (59° 32′ 7·6″ N., 1° 36′ 22·5″ W.). (ii) South-west coast (June 30)—frequent, on very exposed reefs south-west of South Lighthouse (59° 30′ 50·7″ N., 1° 39′ 7·4″ W.); twenty-six of the larger barnacles were collected, and nineteen undamaged specimens measured, as follows: mean length 9·0 mm. (range 6·1–11·2 mm.), mean breadth 8·9 mm. (6·0–12·2 mm.). Sixteen of the twenty-six barnacles contained developing embryos; the least developed were at a very early stage, but the most advanced were quite mature, measured 0·23 × 0·13 mm. (size of egg-case; mean of twenty-five from largest barnacle), with some ready to release nauplii.

The sizes of *C. stellatus* at these new northern limits of its range are comparable with the mean and maximum sizes attained in the Firth of Clyde (personal observations), the Isle of Man[6], and Lancashire[2], and with the largest mean sizes recorded near Plymouth (6·0 mm. mean diameter at an estimated age of four years)[1] and near St. Malo (6·3 mm. after three years growth in an exposed situation)[7]. The sizes of the largest barnacles suggest at least three or four years growth. Thus growth is not inhibited and there was no evidence of abnormal mortality or sterility of either young or old barnacles, such as might be expected if, as has been suggested by several authors, low winter temperatures were critical for survival of the species at the northern limits of its range.

These observations lend support rather to the view that the present over-all limits of distribution of *C. stellatus* on British coasts are probably determined by factors affecting survival of the planktonic larval stages rather than of the hardy adult barnacles. In this respect it is of interest that at least some larvæ in Shetland waters must have survived lower summer surface seawater temperatures (maximum in August 11°–13° C.) than are normally found anywhere else around the British Isles or throughout the North Sea[8,9]. Further, seawater temperatures off south-west England are normally higher from June to November than the Shetland August maximum, suggesting that both the reported failure of the early and late broods in the south-west[2], and the absence of *C. stellatus* east of Swanage, are due to environmental factors that are unfavourable for survival of larvæ in some respect other than a direct temperature effect. These unknown limiting factors could be a shortage or absence of suitable planktonic food organisms at the appropriate time of year, and/or a generally unfavourable chemical environment (cf. the observations of Wilson[10] on the poor survival of larvæ of certain other marine invertebrates in Channel water as compared with Atlantic water).

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Ants *Myrmica rubra* L. and *M. scabrinodis* Nylander as Intermediate Hosts of a Cestode

During recent ecological investigations of the ant fauna of heather moor in the west of Scotland, two of the commonest species in this region, *Myrmica rubra* L.[1] and *M. scabrinodis* Nylander, have been found to be acting as the intermediate hosts of a cestode. The cysticercoids lie freely in the body cavity and are extruded as soon as the cuticle is ruptured. They are ellipsoidal in shape (Fig. 1), measuring 530–700 μ by 340–400 μ, are very active and contain numerous calcareous granules. No suggestion of a cercomere has yet been seen. The larval scolex is often extruded very soon after the cysticercoid is removed from the ant and placed in saline. In most cases the scolex breaks away from the cyst, the rupture occurring at the base of the larval neck, and thereafter it progresses by movements of the suckers.

The dimensions of the scolex vary with the state of contraction; but in its relaxed condition it is approximately 300 μ long by 180 μ in diameter. The rostellar ring is 50–60 μ in diameter and consists

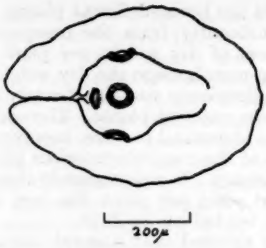

Fig. 1

of a double row of T-shaped hooks pointing outwards (Fig. 2), 13–16 μ in length and numbering about 180. The hooks of one row alternate with those of the other. The rostellum is invaginated in the scolex. The four suckers, 50–65 μ in diameter, are each armed with one compact row of hammer-shaped hooks 8–12 μ in length (Fig. 3). There are about 240 per sucker, all pointing towards the centre.

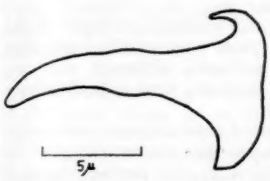

Fig. 2

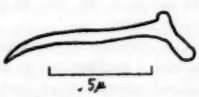

Fig. 3

The cysticercoids have been found in males, queens and workers of both species, the infected ants being detected by an unnaturally dark chocolate coloration affecting the whole cuticle, compared with the dark reddish-brown tint of non-infected individuals. This colour difference may be due to the formation of a melanoid pigment from the excretions of the parasite. Estimates based on dissection of five hundred individuals, of both species, from those regions where the infection occurs suggest that at least 8 per cent are infected. Although the majority of infections consisted of a single cysticercoid, the number may be very much greater. The maximum observed was fifty from one *M. rubra* queen.

As regards the definitive host of this worm, an investigation has shown that the red grouse, *Lagopus scoticus scoticus* (Latham), of the regions examined carry heavy infections of the widespread grouse cestode *Raillietina* (*Paroniella*) *urogalli* (Modeer, 1790), the intermediate host of which is unknown. A comparison of the scolices of these worms and those of the ant cysticercoid suggests that they are identical in all respects; further, no infections have been found in ants from regions other than grouse-moor. Experimental proof of the identity of the cysticercoid is not yet available.

This appears to be the first recorded instance of the above two species of ant acting as the intermediate hosts of a cestode. M. F. Jones and M. W. Horsfall[2], in the United States, have given an account of *Tetramorium caespitum* L. as an intermediate host of *R.* (*Raillietina*) *echinobothrida* (Megnin, 1881), and Ch. Joyeux and J.-G. Baer, in France, mention *Tetramorium semilaeve* André[3], also *Pheidole* sp.[4], as transmitting the same worm. The latter authors further incriminate *T. caespitum* and *Pheidole* sp. as intermediate hosts of *R.* (*Raillietina*) *tetragona* (Molin, 1858), and *Formica rufa* L. as intermediate host of *R.* (*Raillietina*) *friedbergeri* (v. Linstow, 1878).

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Diurnal Rhythms in *Periplaneta americana* L.

In the cockroach *Blatta orientalis* there appears, in both laboratory experiments[1] and in natural infestations[2], a rhythm of activity under normal conditions of light and darkness taking the form of a burst of activity in the early part of the night, mainly before midnight, and a quiescent period in the later part of the night and during the day. This rhythm can be eliminated by keeping the insects under constant light, when activity becomes random; normal activity is, however, continued for at least three days under the new conditions. A similar rhythm occurs in *Periplaneta americana*[3].

The type of carry-over of the rhythm under new conditions suggests that a hormone may be involved in the control of activity rhythms. Experiments have been performed in which two *P. americana* cockroaches have been joined together in parabiosis. The top cockroach, which had had the legs removed and was immobile, had previously been subjected to normal conditions of light and darkness and been found to have a normal rhythm of activity; the bottom, mobile cockroach had been left in constant light for its whole life and had no rhythm of activity. The activity of this parabiotic pair was then measured under constant light and they were found to have a rhythm of activity corresponding closely to that of the 'normal' top cockroach. If left in constant light over a period of six or seven days the rhythm was gradually lost. The reverse positions were also tested, the top cockroach having before parabiosis no rhythm, and the bottom mobile one a normal rhythm. The bottom cockroach continued to show a normal rhythm of activity.

Cloudsley-Thompson[3] has shown that the light acts through the compound eyes and ocelli; painting over both causes a loss of rhythm. He also showed that decapitation caused a loss of rhythm, a feature which is well known in other insects where decapitation causes complete cessation of activity. Roeder maintains[4] that the head ganglia exert a general control over locomotion. If this be so, the loss of rhythm after decapitation does not so much indicate the position of the controlling centre of the rhythm, as that there has been interference with the mechanism by which it is effected.

Two cockroaches which had been kept in constant light and had no rhythm were joined together, the eyes of the bottom mobile one painted over, and the pair placed in normal light and darkness. A normal

rhythm of activity was developed. After painting over the eyes and ocelli of both cockroaches of a pair in which the top one had no rhythm and the bottom mobile one a normal rhythm, the pair still showed a normal rhythm, but lost it in two days.

It would appear from the foregoing experiments that a secretion, carried in either the blood or tissues, is involved in the production of a diurnal rhythm of activity in the cockroach.

Work is proceeding on an investigation of the region forming the secretion.

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Effect of Mineral Status on the Concentration of Rubber in *Hevea brasiliensis*

Under certain conditions, *Hevea brasiliensis* will respond to the application of fertilizers[1,2], which may give an increased yield of rubber per tree[3]. This increase is generally attributed to the enhanced growth and vigour of the tree, which consequently gives a greater output of latex. There is, however, no published evidence to show that the rubber concentration within the tissues can be influenced by the mineral status of the plant. The following describes briefly the main results of an experiment which bears on this point.

Seedlings of clone Tjirandji 1 were grown in sand culture under conditions of complete nutrient supply and also with a deficiency or low level of nitrogen, sulphur, phosphorus, magnesium, potassium, calcium, iron, manganese and boron. The plants were sampled four, five and seven months after sowing. The laminæ were analysed for the mineral constituents while the stems and petioles were bulked together, dried, milled, extracted with warm benzene and the rubber in the extract determined after evaporation and alkaline hydrolysis[4].

The values obtained for the total dry weight of shoot and roots per plant for the complete nutrient treatments were significantly higher than those of all other treatments with the exception of boron deficiency, which did not show a depression until the last sampling. The disparity between the complete nutrient plants and those of other treatments became more marked with time. Leaf deficiency-symptoms were observed in plants without, or with low supplies of, each of the elements except calcium and boron.

At the first sampling the 'complete nutrient' plants contained a significantly higher concentration of rubber in the stems and petioles than plants receiving other treatments. The decrease obtained in the boron-deficient plants was striking even though they did not exhibit leaf symptoms and appeared, visually, to be the most healthy and vigorous plants in the experiment.

At the second sampling, when the plants were five months old, the rubber concentration in the stems and petioles of the complete nutrient plants was still significantly higher than for the plants deficient in iron or boron. The rubber concentration was particularly low in the boron-deficient plants, which did not differ significantly from the complete nutrient plants in respect of dry weight per plant.

At the seven-month stage the dry weight yield per plant for each deficiency was significantly lower than for the complete nutrient plants. The concentration of rubber in the stems and petioles, however, generally exceeded that of the complete nutrient plants except for boron deficiency. It was apparent that whenever the dry weight yield per plant was low, the rubber concentration tended to be high.

Thus it was inferred that mineral status will only have a direct effect on rubber concentration in the earlier stages of growth when the yield differences between complete nutrient and deficiency treatments are relatively small. The gradual decrease in the rubber concentration observed with each successive sampling was probably due to the increasing proportion of non-latex producing tissue and the mode of expression of the results as a proportion of the total stems and petioles per plant. If it proves possible in future work to estimate the rubber in newly produced leaves or young tissues, a direct effect of mineral status on rubber concentration may even be obvious in old plants.

The concentration of the withheld nutrient in the laminæ of the deficient plant was usually lower than that in the complete nutrient, although this was not always so for the sulphur- and iron-deficiency treatments.

The results demonstrated that nutrient deficiencies caused a reduction in the rubber concentration of the bulked stems and petioles in the earlier stages of growth only, before the differential effect of mineral treatment on yield response had become acute. The total rubber content of the plant was, however, governed by the dry weight production, which in turn was dependent on mineral status. Accordingly it must be expected, under field conditions, that where nutrient deficiencies are sufficiently severe to cause an appreciable decrease in the vigour and dry-weight production of the plant, a smaller yield of rubber per tree will result.

A fuller account of the experimental results will appear in the *Journal of the Rubber Research Institute of Malaya*.

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Significance of the Ratio between the Water-soluble Aromatic and Nitrogen Constituents of Apple and Pear in the Host–Parasite Relationships of *Venturia* Species

Various workers have directed attention to the possible importance of aromatic host constituents in associations between plants and pathogens[1–3]. Recent work at East Malling[4,5] on the water-soluble constituents of apple and pear leaves and stems has made possible a detailed investigation of the biochemical aspects of host–parasite relations in *Venturia*

inaequalis and *V. pirina*, the causal fungi of apple scab and pear scab respectively.

Cultural studies have shown that the aromatic fraction of the water-soluble constituents (that is, the complex mixture of plant phenols extracted by ethyl acetate) and its separate main components may be strongly inhibitory to the growth and sporulation of the pathogen, depending on the complexity and amount of the nitrogen source. A high level of amino-nitrogen in the culture medium, for example, may result in complete degradation of the aromatic compounds by exogenous activity of a polyphenol-oxidase system secreted by the fungus. Conversely, an inorganic, or low-level amino-nitrogen, supply favours the inhibitory activity of aromatic compounds, resulting in all stages between reduction in sporulation and complete inhibition of growth. Marked differences in reaction to a given aromatic/nitrogen ratio have been observed between different clones of each pathogen.

By injection of inoculated apple and pear shoots with the aromatic fraction of leaf extracts, and urea, separately and in combination, evidence has been obtained of a similar mechanism operating *in vivo*. Using potted apple and pear trees under glass, shoots were enclosed in polythene-sleeve moist chambers as described by Stanton[6] and inoculated by spray application of conidial suspensions. Injections were carried out during the incubation period of infection using a modification of the Roach method[7,8] of petiole injection to ensure even permeation of the leaves on the shoot thus injected. Nine replicate leaves of similar age on nine shoots were used in each treatment, and disease expression was recorded by estimation of percentage cover by scab lesions on both leaf surfaces. The accompanying table is an example of the results obtained in a series of inoculation and injection experiments. Water injection had no effect on scab incidence as compared with uninjected shoots.

TOTAL SCAB (*V. inaequalis*, CLONE E_1) IN EACH INJECTION TREATMENT ON COX'S ORANGE PIPPIN

Shoots injected with	Days after inoculation			
	14	18	21	28
Water	5·3	10·3	15·6	56·3
Cox aromatic fraction 1 per cent	0·0	0·1	0·1	3·3
Urea 0·5 per cent	17·0	47·2	61·2	102·1
Cox aromatic fraction 1 per cent and urea 0·5 per cent	23·1	24·3	31·6	54·3

Injection of the aromatic fraction of the constituents of Cox's orange pippin reduced infection markedly, while urea had the opposite effect. A mixture of this fraction and urea had no effect on the final level of infection as compared with water injection.

Mature leaves of all varieties are immune to infection. It was observed that injections produced their maximum effect on leaves approaching the mature resistant stage. It is thought that the aromatic/nitrogen ratio, at this stage of leaf development, can be most effectively altered by injection, as relatively small changes may inhibit or stimulate the pathogen. Work on the quantitative differences between young leaves of varieties characterized by varying degrees of resistance and between susceptible young leaves and immune mature leaves of the less resistant varieties is in progress.

It is suggested that the reaction of a clone of the pathogen to the aromatic/nitrogen ratio of the host may be a critical factor controlling the level of pathogenicity observed.

A full description of these results will be given elsewhere.

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Affinity of Sambucyanin for Nucleic Acids

I RECENTLY pointed out[1] the existence in *Sambucus nigra* berries of a dyestuff (sambucyanin) which can be used as a nuclear stain. Further investigations enabled me to ascertain that such a dye has a selective affinity for nucleic acids: actually, both deoxyribonucleic acid and ribonucleic acid are markedly coloured red *in vitro* by sambucyanin, the affinity for this dye not being shown by chemical and enzymatic hydrolysis soluble products of acids. Likewise, the stainability of cellular elements in tissues disappears after using specific nucleases.

Cytochemical demonstration of nucleic acids by means of sambucyanin is carried out, as a rule, on fixed material; however, it is possible to effect cellular element staining even supravitally, using concentrated solutions. The best results are attained by using the dyestuff in the fresh state and avoiding fermentation. Purified pigment can be obtained from raw sambucyanin by means of salification with hydrochloric acid in methanol and precipitation of hydrochloride with sulphuric ether.

Staining method. (1) Dip sections of tissues (fixed in alcohol or formalin) in a 10 per cent aqueous solution of sambucyanin for ten minutes. (2) Wash in distilled water. (3) Operate a careful differentiation in 80 per cent alcohol in order to remove any aspecific dye adsorption on the part of other tissue elements (calcareous concretions, etc.). For a quick differentiation alcohol lightly acidified with acetic acid can be used. (4) Handle eventual contrast staining with a 1 : 1,000 aqueous solution of light green for about one minute. (5) Again rinse in distilled water. (6) Dehydrate in absolute alcohol, clear in xylol and mount in neutral balsam.

To carry out supravital staining, mix a 25 or 50 per cent sambucyanin solution with the specimen material suspended in neutral liquid in equal parts, and allow it to remain for some minutes before checking: nucleic acids become red.

Nucleic acid staining with sambucyanin affords, in comparison with other methods, higher sensitiveness and specificity; it gives a more constant effect and is easier to use, as well as offering the possibility of supravital use.

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Dec. 18.

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Alkaloids in Germinating Seeds of *Atropa belladonna*

During recent work on alkaloid biogenesis in *Atropa belladonna*, the results of which will be published elsewhere, we used James's method for demonstrating alkaloids in solanaceous meristems[1]. This method is based on the formation of a red precipitate around a piece of plant tissue as a result of the diffusion of alkaloid in a potassium iodide – iodine solution (Bouchardat's reagent).

James tacitly assumes that the alkaloids demonstrated in germinating seeds are tropane alkaloids; but as Bouchardat's reagent is non-specific, there is insufficient proof for this.

Paper chromatography[2] of extracts of germinating seeds and seedlings of *A. belladonna* showed that the alkaloid which appears first is not hyoscyamine, or scopolamine, apoatropine, belladonnine or tropine; but an unidentified, strongly basic alkaloid, which probably is bellaradine, first isolated by King and Ware from Bulgarian *A. belladonna* root[3].

Afterwards, scopolamine and then hyoscyamine appear.

P. Reinouts van Haga

Laboratory for Technical Botany,
Technical University,
Delft. Dec. 17.

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Reversible Photo-oxidation of a Cytochrome Pigment in Photosynthesizing *Rhodospirillum rubrum*

The investigation reported here is a continuation of experiments[1] on reversible changes in light absorption in purple bacteria induced by irradiation. It presents evidence which indicates that, in living bacteria in the absence of oxygen and in the presence of substrate, a cytochrome pigment is oxidized by illumination and is reduced in the dark. The bacteria used were vigorously growing, one or two days old, *Rhodospirillum rubrum*, strains 1 and 4. The growth medium for strain 1 was tap-water containing 1 per cent peptone, and for strain 4 tap-water with 1 per cent peptone and 0·5 per cent sodium chloride.

The apparatus for measuring the changes in absorption was a modification of the sensitive differential spectrophotometer described earlier[1]. The change in absorption was brought about by illuminating a bacterial suspension with a beam of variable intensity, and the change was measured by means of a monochromatic scanning beam the wave-length of which could be varied. This scanning beam was at right angles to the actinic beam. It was too weak to cause a change in absorption. The source of actinic radiation was a tungsten lamp with a filter transmitting beyond 670 mμ.

Irradiation of a suspension of *Rhodospirillum rubrum* strain 1 in its growth medium under anaerobic conditions produced marked changes in absorption at about 430 mμ at rather low actinic intensities. The original absorption was restored in the dark. These changes were complete in the time of the order of a second. The changes in absorption coefficients at different wave-lengths of a bacterial suspension produced by a constant actinic beam are plotted in Fig. 1. This curve we call the spectrum of the change in absorption. If the bacteria were suspended in 0·03 *M* sodium acetate plus 0·05 *M* phosphate buffer *p*H 6·8, under anaerobic conditions, instead of in peptone, a similar spectrum was produced by illumination, as measurements at a few wave-lengths indicated. A similar spectrum of the change in absorption was found for the more anaerobic strain 4 of *Rhodospirillum rubrum*, when measured in its growth medium.

At high actinic intensities a different spectrum of the change in absorption is found, the shape of which depends upon the intensity. This spectrum probably is a combination of the spectrum of Fig. 1 with another spectrum. The infra-red part of this other spectrum has been published earlier[1]. The changes in absorption in the infra-red are probably due to changes in bacteriochlorophyll absorption.

The spectrum of the change in absorption of the *Rhodospirillum* suspension (Fig. 1) has a positive maximum at about 427 mμ and a negative one at about 409 mμ. Except for a shift of the maxima of about 7 mμ to longer wave-lengths, the spectrum of the change in absorption of the bacteria is similar to the spectrum obtained[2] by subtracting the spectrum of reduced cytochrome *c* from that of oxidized cytochrome *c* (Fig. 1, dotted line). This indicates that a cytochrome pigment is oxidized by a light reaction and is reduced by a dark reaction, as indicated by the restoration of the original absorption in the dark.

Van Niel[2] provided evidence that the last step or steps of the photosynthetic dehydrogenation of the substrate in *Rhodospirillum rubrum* are the same as the last steps in the dehydrogenation of the substrate in the dark by respiration. The respiratory dehydrogenation presumably proceeds by way of a cytochrome system[4]. A cytochrome has been extracted[5,6] from *Rhodospirillum rubrum* strain 1 similar in reducing properties to cytochromes *c*, but, unlike *c*, not oxidizable by cytochrome oxidase from pig heart[6].

Although it is not yet possible to tell whether this cytochrome is identical with the cytochrome (Fig. 1) that is oxidized by irradiation, we may say that our experiments indicate that the photosynthetic oxidation of the substrate in *Rhodospirillum rubrum* is mediated by a cytochrome pigment.

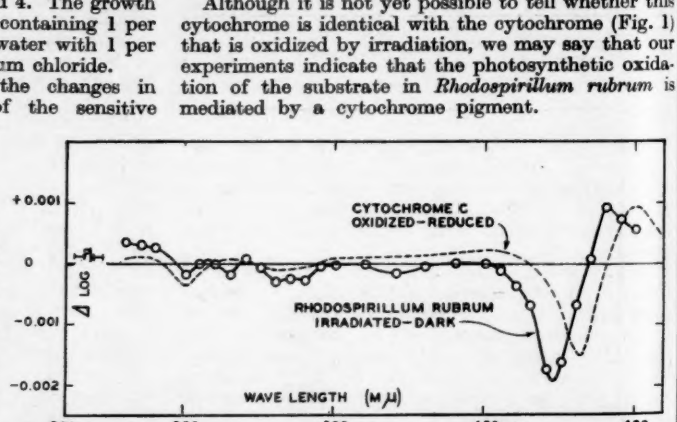

Fig. 1. Spectrum of the change in absorption of a suspension of the non-sulphur purple bacterium *Rhodospirillum rubrum* strain 1 produced by a low actinic light intensity. Difference of absorption coefficient in the light and in the dark is plotted as a function of the wave-length of the scanning beam. The absorption coefficient of the suspension at 880 mμ, corrected for scattering, was 0·9. The figure shows also the difference of absorption spectra of pure oxidized and reduced cytochrome *c* according to Lundegårdh (ref. 2)

A detailed account of these and related experiments will be published elsewhere.

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Dec. 22.

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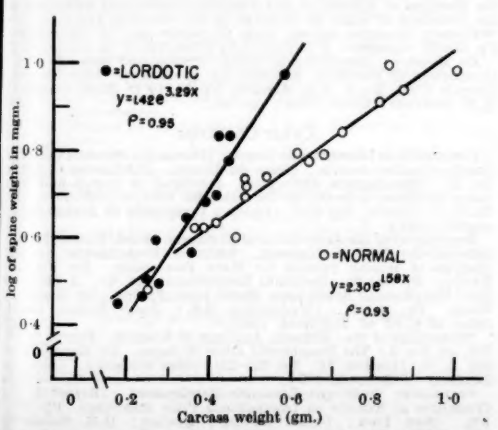
Composition of Bone and Muscle from the Lordotic and Normal Guppy, *Lebistes reticulatus*

The hereditary nature of an abnormality of the vertebral column has been established for at least two species of fishes: *Oryzias latipes*[1] and *Lebistes reticulatus*[2–5]. The biological nature of the mutation is fairly well understood; but there is a paucity of information concerning the chemistry of the bone and tissues from these mutant fishes, although Harrison[4] found the total body calcium of lordotic *Lebistes* to be high. Further studies on the distribution of bone and muscle constituents from these fishes is the basis for this communication.

Mutant *Lebistes* were reared and maintained in the laboratory[6] while normal fishes were obtained commercially. For study, the fish were killed in boiling water. After evisceration, the carcass was weighed, the spinal column was removed and cleaned of adhering tissue, and thoracic and lumbar muscle was obtained free of skin and scales. Analytical procedures were performed by methods previously described in detail[7].

As shown in the accompanying figure, the log weight of the vertebral column versus carcass weight is adequately described by an exponential equation for both the mutant and normal strains. However,



Weight of the spinal column versus carcass weight for lordotic and normal female *Lebistes*

Table 1. Composition of the Vertebral Column from Male and Female Lordotic and Normal *Lebistes**

	Lordotic	Normal	"t"†	P
Calcium	14·6 ±0·30‡	12·2 ±0·43‡	4·73	<0·01
Phosphorus	7·6 ±0·18	7·2 ±0·13	1·74	>0·10
Ca/P	1·93 ±0·05	1·71±0·05	3·09	<0·01
No. of determinations	23	22	—	—

* All values are expressed as the percentage of dry fat-free bone.

† Student's "t" value. From Snedecor, G. W., "Statistical Methods for Research Workers".

$$"t" = \frac{M_1 - M_2}{\sqrt{\left(\frac{\Sigma d_1^2 - \Sigma d_2^2}{N_1 + N_2 - 2}\right)\left(\frac{1}{N_1} + \frac{1}{N_2}\right)}}.$$

‡ Standard error $= \sqrt{\frac{\Sigma d^2}{n(n-1)}}$

the slope of the line of regression calculated by the method of least squares is greater for the lordotic (3·29) than for the normal (1·58), and the correlation coefficient (*P*) is high.

The difference in bone weight is associated with a significantly greater concentration of calcium in the vertebral bone of the mutant fish (see Table 1); but the phosphorus concentration remains the same. These data are average values of bone obtained from both sexes since no significant differences between the sexes was apparent.

The lordotic mutation not only affects the anatomy of the vertebral column but also disturbs the anatomical arrangement of the thoracic and lumbar musculature[4]. However, various analyses of muscle tissue indicate no differences in chemical constituents between the two strains (see Table 2).

Table 2. Composition of Muscle from Lordotic and Normal Female *Lebistes*

	Lordotic	Normal
Water (% wet weight)	77·7 ±0·3* (14)	77·1 ±0·4* (12)
Fat (% dry weight)	6·5 ±0·7 (14)	4·6 ±0·6 (12)
Protein† (% fat-free dry weight)	85·2 ±0·9 (12)	85·0±0·7 (12)
Calcium " " "	0·97±0·06 (10)	1·03±0·11 (12)
Phosphorus " " "	1·19±0·05 (10)	1·29±0·08 (12)
Ca/P	0·77±0·03 (10)	0·80±0·03 (12)

* Standard error.

† Protein was determined from nitrogen values × 6·25.

Numbers in parenthesis indicate number of analyses performed.

It is apparent from these studies that the lordotic mutation is associated with changes in the mechanism of calcification and formation of vertebral bone.

This investigation was supported in part by a grant in aid from the Society of Sigma Xi—Resa Research Fund. I am indebted to Messrs. W. Schaumberg and J. Detrich, of Crescent Fish Farms, New Orleans, La., for normal fish and generous supplies of live fish food.

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2 Goodrich, H. B., *et al.* (Abstract), *Genetics*, **28**, 75 (1943).
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FORTHCOMING EVENTS

Monday, April 12

Society of Chemical Industry, Crop Protection Panel of the Agriculture Group (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Fourth Annual General Meeting. Dr. R. A. E. Galley: "Some Pest Control Problems in the Colonies".

Tuesday, April 13

Zoological Society of London (at the Zoological Gardens, Regent's Park, London, N.W.1), at 5 p.m.—Scientific Papers.

Illuminating Engineering Society (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 6 p.m.—Mr. H. M. Cartwright: "Illuminants for Colour Reproduction and Printing".

Society of Chemical Industry, Plastics and Polymer Group (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Dr. R. J. W. Reynolds: "Relation Between Chemical Constitution and Properties of Polymers".

Royal Aeronautical Society (in the Library, 4 Hamilton Place, London, W.1), at 7 p.m.—Dr. H. Sutton: "Some Aspects of Modern Aircraft Materials".

Wednesday, April 14

Geological Society of London (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. R. W. D. Elwell: "The Lithology and Structure of a Boulder Bed in the Dalradian of Mayo, Ireland"; Dr. F. H. T. Rhodes: "The Conodont Fauna of the Keisley Limestone".

Society of Chemical Industry, Food Group (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Annual General Meeting. Mr. G. S. Bishop: "The Storage and Distribution of the Nation's Food".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Lecturer (Grade III or II) in Philosophy—The Registrar, The University, Bristol 8 (April 15).

Lecturer (with good honours degree and teaching experience, and preferably other postgraduate industrial or research experience) in Physical Chemistry, and an Assistant Lecturer (with a good honours degree, and teaching experience) in Organic Chemistry, at Leeds College of Technology—Chief Education Officer, Education Department, Leeds 1 (April 17).

Senior Assistant Chemist (preferably with waterworks experience, and a member of the Royal Institute of Chemistry, or with an honours degree in chemistry)—The General Manager, Bristol Waterworks Company, Telephone Avenue, Bristol 1 (April 20).

University Demonstrator (with an honours degree in engineering, preferably combined with some agricultural experience) in Agriculture—The Secretary, School of Agriculture, Downing Street, Cambridge (April 28).

Whitley Professor of Biochemistry—The Registrar, University Registry, Oxford (April 29).

Adviser of Studies in Science—The Secretary of University Court, The University, Glasgow (April 30).

Assistant Lecturer, and a Tutor in the Department of Geography—The Registrar, The University, Liverpool (April 30).

Mycologist in the Plant Pathology Department—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (April 30).

Research Officer (Physicist) (with an honours degree in science, or equivalent qualifications, and with research experience in the use of X-ray diffraction, preferably as applied to studies of the structure of proteins or high polymers) in the Biochemistry Unit, Wool Textile Research Laboratories, Commonwealth Scientific and Industrial Research Organization, Parkville, Melbourne, to participate in an intensive programme of research on the structure of wool and other fibrous proteins by chemical and physical methods—The Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting 462/51 (April 30).

Entomologist (with at least a specialized degree normally involving a four-year university course, and preferably with a knowledge of botany and field ecology) in the Department of Agriculture (Tsetse Fly Operations Branch), Southern Rhodesia Government, for work which may embrace laboratory and field research or investigation on tsetse fly, field reclamation and survey work—The Secretary, Southern Rhodesia Government, Rhodesia House, 429 Strand, London, W.C.2 (May 1).

Physicist or Metallurgist, Research Officer or Senior Research Officer grade (Ph.D., with additional research experience, or equivalent qualifications essential), in the Division of Tribophysics of the Commonwealth Scientific and Industrial Research Organization, at the University of Melbourne, for work concerned with problems of plastic deformation and phase transformation—The Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting 370/81 (May 1).

Professor of Physics at Rhodes University, Grahamstown, South Africa—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (South Africa, May 1).

Chair of Physical Chemistry tenable at the Imperial College of Science and Technology—The Academic Registrar, University of London, Senate House, London, W.C.1 (May 5).

Research Officer (with an honours degree in science, with biochemistry or chemistry as major subject, and research experience, preferably in some biological field) in the Physical Chemistry Section, Division of Industrial Chemistry, Commonwealth Scientific and Industrial Research Organization, Fishermen's Bend, Victoria, Australia, to participate in a programme of research on the fixation of nitrogen by biological systems—Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting 590/447 (May 6).

Senior Research Officers (3) (preferably with specialized postgraduate training in a branch of science applied to agriculture, for example, plant physiology, soils, crop husbandry or agricultural engineering) to take charge of sugar cane research in the main ecological divisions of the sugar area—The Director of Research, Sugar Manufacturers' Association (of Jamaica), Ltd., Sugar Research Department, Mandeville, Jamaica, British West Indies (May 7).

Lecturer in Geography at the University of New England, Armidale, New South Wales, Australia—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (May 10).

Esso Student (with an honours degree in chemistry or engineering) in Chemical Engineering—The Registrar, Imperial College of Science and Technology, London, S.W.7 (May 14).

Professor of Mechanical Engineering, and a Professor of Civil Engineering, at the University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (South Africa, May 15).

Assistant Lecturer (preferably with special qualifications in stratigraphy and palæontology) in Geology—The Registrar, University College of South Wales and Monmouthshire, Cathays Park, Cardiff (May 29).

Lecturer (with a good honours degree in botany, and research experience, preferably in genetics) in Botany, at the Imperial College of Tropical Agriculture, Trinidad, British West Indies—The Secretary, The Imperial College of Tropical Agriculture, 40 Norfolk Street, Strand, London, W.C.2 (June 30).

Lecturer (with knowledge of industry, and preferably with a knowledge of latex) in Rubber Technology, a Lecturer (chemist or physicist, preferably with some practical experience) in Plastics Technology, and a Lecturer in Physics—The National College of Rubber Technology, Northern Polytechnic, Holloway, London, N.7.

Master to teach Biology to University Scholarship standard—The Headmaster, Haberdashers' Aske's Hampstead School, Westbere Road, London, N.W.2.

Scientific Officer (Physicist) (with first- or second-class honours degree in physics, with mathematics as subsidiary subject, or equivalent qualifications) in the Department of Scientific and Industrial Research, Water Pollution Research Laboratory, Stevenage, for research on physical problems arising in the study of polluted rivers—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A85/54A.

Scientific Officers (with first- or second-class honours degree, or equivalent, in physics or mathematics) with the Air Ministry, for operational research on a wide variety of problems, in London and the provinces, under the direction of the Scientific Adviser to the Air Ministry—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.285/52A.

Senior Experimental Officers (Ref. 566), Experimental Officers (Ref. 567), and Assistant Experimental Officers (Ref. 568) (with at least H. S. C. in science subjects) in the Department of Atomic Energy, Culcheth, near Warrington, for duties connected with analysis of materials arising in research on metallurgical and chemical processes involving rare metals—The Department of Atomic Energy, Industrial Group Headquarters, Risley, Warrington, quoting appropriate Ref. No.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Toxic Chemicals in Agriculture: Residues in Food. (Report to the Ministers of Agriculture and Fisheries, Health, and Food, and to the Secretary of State for Scotland of the Working Party on Precautionary Measures against Toxic Chemicals used in Agriculture.) Pp. iii+32. (London: H.M. Stationery Office, 1953.) 1s. 6d. net. [102

Air Ministry: Meteorological Office. Professional Notes No. 108: Comparison of the Wind Recorded by Anemograph with the Geostrophic Wind. By W. A. L. Marshall. Pp. 26. (M.O. 524h.) (London: H.M. Stationery Office, 1954.) 1s. net. [122

Other Countries

Companhia de Diamantes de Angola. (Diamang.) Servicos Culturas. Dundo—Lunda—Angola. Museo do Dundo. Publicacoes Culturais No. 21: Grasshoppers (Orthoptera, Acrididae) of Angola and Northern Rhodesia, collected by Dr. Malcolm Butt in 1927-1928. By Dr. B. P. Uvarov. Pp. 217. (Lisboa: Companhia de Diamantes de Angola, 1953.) [22

Department of the Army-Corps of Engineers. Beach Erosion Board: Office of the Chief of Engineers. Technical Memorandum No. 35: Analysis of Moving Fetches for Wave Forecasting. By Kenneth Kaplan. Pp. iv+39. Technical Memorandum No. 42: A Study of Sand Movement at South Lake Worth Inlet, Florida. By George M. Watts. Pp. iv+24. (Washington, D.C.: Beach Erosion Board, Office of Chief of Engineers, 1953.) [22

Proceedings of the California Academy of Sciences. Fourth Series. Vol. 28, No. 5: The Trombiculid Mites of Japan. By Manabu Sasa and E. W. Jameson, Jr. Pp. 247-321. (San Francisco: California Academy of Sciences, 1954.) [22

Commodity Trade and Economic Development. (Report of the Committee of Experts on International Price Relations.) Pp. vii+102. (New York: United Nations; London: H.M. Stationery Office, 1953.) 75 cents; 5s.; 3 Swiss francs. [22